Sectional Volume No. 11.

Ministry of Agriculture and Fisheries.

COLLECTED LEAFLETS

ON

INSECT PESTS

OF

FARM & GARDEN CROPS

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By Metchim & Son, Princes Street, Westminster, S.W.1.

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MINISTRY OF AGRICULTURE AND FISHERIES,
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INTRODUCTION.

Contents of the Book.—The number of insect pests attacking farm and garden crops is large—so large that only a comparatively small proportion of them can be dealt with individually in this collection of leaflets. On the other hand the control measures which it is possible to take are few, and as the majority are illustrated by one or other leaflet, hints may be obtained not only as to how to deal with the particular pests described in this volume but with many others which do similar damage.

Contents of the Leaflets.—Most leaflets are divided into certain sub-sections:—"Plants Attacked and Nature of Damage," "Description and Life-History," and "Measures of Control." It is sometimes complained that these sub-sections contain too much "technical matter" and that all that is required is "how to recognise the pest" and "how to control it." Now recognition and control are exactly the objects at which each leaflet aims, but the necessary information cannot be given without the introduction of some so-called "technical matter," particularly in relation to the habits and life of the pest. The following consideration will make this clear. Insects, though very small, are creatures with their own habits and ways, living in a perfectly wild state just like birds, fish, or any wild animal. In order to fish successfully, whether for minnows or sharks, the first essential is to understand the habits of the fish. This applies also to shooting, no matter whether the game is a tiger or a rabbit. A man, for instance, who realised that his crops were being eaten by rabbits but knew nothing whatever about them—even whether they ran or burrowed underground—would not make much of a bag, or protect his crops successfully!

The same considerations apply to insect pests—to hunt or control them successfully it is essential to know as much as possible of their habits, and in dealing with insects it is as unreasonable to object to the use of certain special—so-called "technical"—terms as it would be to object to the use of such terms as warren in the case of rabbits, leveret in the case of young hare, or brush in the case of a fox's tail!

A useful leaflet, therefore, must contain some technical matter, but it is hoped that in spite of this the whole will be read, for only material is put in which may have a definite bearing on the control of pests, while the technical terms are reduced to a very few which may easily be learnt.

(64987) P.2044/S.R.76. 3,000. 4/26. M. & S. Gp.95.

The sections in a leaflet follow on naturally. The first thing which attracts attention to a pest is the damage. Under "Plants Attacked and Nature of Damage" is given a list of the crops likely to be attacked and the characteristic signs of injury. Under the next section, "Description and Life-History," are described, the appearance of the pest in its various forms, and its life-history or habits, showing where it lives at each season of the year and which are its vulnerable stages. With this information it is then possible to follow the suggestions given under "Measures of Control," carrying out each operation with discretion and not by rule of thumb—a most important point, for success is often dependent on adapting a measure to meet special local conditions.

Notes on Insects in General.—As it is impossible to deal separately with many insects in the leaflets themselves, a few general notes may be found useful.

Description.—Insects belong to a group of creatures characterised (1) by the possession of a jointed body which is supported not by bones inside but by a hard horny skin, and (2) by the possession on one or more segments of the body of jointed "appendages" which may be modified to act as legs, jaws, antennae (feelers), &c. Strictly speaking, the term *Insects* should be confined to the creatures in the group with only three pairs of legs (in addition to other characteristics), such, for instance, as moths, beetles or bugs, but for practical purposes the name usually includes the groups containing mites (red spiders) and spiders with four pairs of legs, and the millipedes and centipedes with many pairs of legs. From the practical point of view no detailed knowledge of the various organs of the body is necessary, but it is helpful to know a little of the features which characterise an insect as a living creature.

The *body* consists of three parts—the *head*, the *thorax* and the *abdomen*.

(*a*) The *head* bears the antennae (or "feelers"), which are not only organs of touch but are probably connected with other senses, possibly in some forms with smell. (Little, however, is known about the senses of insects except that by some means they smell and probably hear also.) There are also on the head the eyes which when well developed enable them to see the shape of things, or in other cases may be only sufficient to detect light or darkness. The mouth, on the underside of the head, is surrounded by "appendages" which vary in the different groups, in some taking the form of biting jaws and finger-like organs to push food between them, while in others the same organs may be modified so as to form a "trunk"

enabling the insect to bore holes and suck up juices. From the practical aspect it is very important to recognise the difference in feeding habits which correspond with the difference in the mouth parts, since species with jaws can eat solid matter, while those with trunks merely suck up juices through a minute hole.

(*b*) The second section of the body, the *thorax*, is essentially the part connected with movement. It usually carries three pairs of legs and it may also be provided with one or two pairs of wings.

(*c*) The third section of the body, the *abdomen* (often called the " tail "), corresponds more or less with the lower part of the body in man, and contains the organs of reproduction and the gut, in passing through which food is digested. Extending down the whole length of the insect, just under the upper surface, is a long tube which pumps the blood, beating like the heart, to which it may be compared.

It will be noticed that no reference has yet been made as to how insects breathe. This is because they have entirely different " machinery " from that in man. In the latter case the air is taken into the lungs and the oxygen is absorbed by the blood and carried to wherever it is needed. In insects the same result is obtained but by a " short cut " since they have a series of holes (spiracles) along the sides of the body (usually thorax and abdomen) which lead into tubes passing to every part, so enabling air to flow freely in and out. Every organ has therefore a direct air supply and there is no need for lungs. In controlling insect pests the special method of breathing is an important point to remember.

Finally, as regards the structure, the statement may be recalled that insects have no bones, but depend for their support on their " skin," which in consequence may be regarded as their skeleton, being either hard or tough and in many cases forming almost an armour plate. This armoured character of the skin makes many insects difficult to kill.

Life-History.—In addition to a knowledge of the structure of insects, it is helpful, or even necessary, to have some idea of their life-history—their methods of breeding and development. The usual method of starting life is from an egg laid by the mother, but the young which are hatched from these eggs often at first have little likeness to their parents. In course of time they grow to resemble the latter, but in so doing pass through stages so unlike in shape or form that it seems hardly credible they can be the same creature. This great change of form is perhaps explained by the fact that insects at the different stages of their lives concentrate strictly on " the business in hand," definite periods of their

existence being devoted very largely to one object. This is clearly shown in the case of the White Butterfly, the egg of which gives rise to a caterpillar with one main object, and that is to eat. The caterpillar having eaten all it requires at that period of its life, turns to a chrysalis, a stage in which the insect neither feeds nor travels but undergoes great changes internally. From the chrysalis comes the butterfly which, though it may sip a little nectar, concentrates on breeding and spreading the species. In each stage the form of the insect is such as to adapt it to one object at a time—the caterpillar with its jaws and absence of wings is fitted to do little else but feed, the chrysalis must remain outwardly immovable, and the butterfly with wings, with a trunk which does not allow of its taking solid food, and with breeding organs well developed, is clearly adapted to propagating the species.

The bearing of all this on insect control is that it is very necessary to be on the lookout for the different stages, which though not in all cases as strongly marked as in the butterfly, nevertheless always occur to a greater or less extent. Obviously the stage when damage is likely to be done is that adapted to feeding, but it serves equally well if the pests are destroyed in one of the other stages. The great thing therefore is to look for the condition in which the insect is most vulnerable and to tackle it then, even though at the time it may be doing no actual damage. Finally, in connection with breeding, it may be pointed out that some groups of insects such as Aphides (Green Fly) have found it possible to do without males for many generations, the females producing young without pairing, while in a few cases (certain sawflies) males appear to have been nearly lost altogether. This power of dispensing with males naturally causes such insects to prove dangerous enemies. for instead of about half the total population being able to produce young, all can. Indeed throughout the insect world it is possible to see how every development has been regulated by the supreme necessity for rapid reproduction and it is this perpetual increase which so threatens the crop-grower.

Nature's Control of Pests.—Insect pests are to a considerable extent kept in check by natural agencies. Thus, while for a year or several years the destruction wrought by a pest may rise in a wave which seems to threaten the very existence of a certain crop, natural agencies sooner or later step in and again reduce the numbers of the pest—and in consequence the damage done by it—to more reasonable proportions. Thus over a term of years a balance is more or less preserved. In times gone by this natural control was perhaps sufficient to meet commercial needs, but now with keen competition and the call for high quality and high

yield, the average damage due to pests is more than the industry can bear. It is therefore necessary to add artificial measures to the natural agencies already at work. Any consideration of such measures would, however, be incomplete without some further reference to the chief agencies of natural control—*i.e.*, weather conditions, the attacks of other insects, and of birds.

Of these agencies, the *weather* admits of no interference on behalf of crop-growing, but there is some hope that in years to come a greater knowledge of the effects of weather on insects may make it possible to predict the appearance or absence of serious epidemic pests, and so enable measures against them to be taken in time. Work to this end is going forward.

As regards *birds*, the pros and cons of protection, legal and voluntary, are gradually being placed upon more sure and sensible foundations, and there is no doubt that insectivorous species are among the very best friends of the farmer and gardener and therefore to be encouraged whenever possible. At the same time the conditions of modern agriculture, with the necessity for destroying weeds and clearing up overgrown hedgerows, limit to some extent the chief means of encouraging the more useful birds (by the provision of suitable breeding places). It seems clear therefore that useful as birds are as allies, it will never be possible to rely upon them alone for winning the fight against insect pests.

The remaining great natural factor in regulating the number of pests is found in *beneficial insects**—that is to say, those insects which prey upon others. Such insects are always of great value and are sometimes of overwhelming importance in saving crops from their enemies, and of all natural means of control they perhaps offer the most scope for human interference. It is, however, not yet possible to increase beneficial insects sufficiently to render the use of purely artificial methods of control unnecessary, and in the case of practically every pest some such measure as spraying is required. In this connection it cannot be too strongly emphasised that artificial control not seldom results in the destruction of both friend and foe together, and that, therefore, having once taken over a responsibility from Nature, the work must in future be thorough or epidemics may be even more frequent than they were in former times, when matters were left to take an entirely natural course.

Methods of Controlling Insect Pests.—Measures for keeping insect pests in check may be divided roughly into Indirect, which tend to make conditions unfavourable to

* *See* the Ministry's Miscellaneous Publications No. 37, *Beneficial Insects* (with 2 coloured plates). Price 4d.

pests in general, and Direct, which are designed to destroy a certain definite pest.

Since there is a radical difference in the nature of the measures to be applied in the case of farm and garden, the two must be considered separately.

Farm.

Indirect Measures.—From what has been said above it is clear that insects in their various stages are adapted to certain special conditions—the caterpillar to living and feeding on a leaf, the butterfly to breeding, and so on. The object of all indirect measures is to make the conditions unsuitable to pests in one or more of their stages and so cut the cycle. An instance or two will show what is meant.

Flea Beetles (often known as Turnip Fly), Mangold Flea Beetles, Mustard Beetles and Pea Weevils, as well as many other harmful insects, are compelled to find some shelter in which to spend the winter—as, for instance, in hedge bottoms, dyke sides, heaps of stackyard rubbish, or in the rough tussocks of poor pastures. It is impossible to do away with all shelter for insects on a farm, but the more rubbish that is burnt and the more closely pastures are fed down, the fewer insects will be present in the spring to start an attack on the young crops. Since insects begin to spread from their winter shelter during the first warm spell in spring, burning before the middle of February will do much more good than if it were delayed till March.

Again, most insect pests feed not only upon crops but also upon weeds, and they may be dependent on the latter for food at times when the proper crop is not available. The Black Fly (or Aphis) of beans, for instance, feeds upon docks and poppies, and the maggots of the Gout Fly upon Couch Grass (Twitch). There are, of course, better reasons for destroying weeds than the fact that they serve to feed insect pests, but nevertheless this fact gives an additional point to the campaign against weeds, and serves as a reason for clearing up odd corners which might otherwise be neglected. Perhaps the disadvantage of all indirect measures of this type is that it is not possible to estimate the actual money gain, but it may certainly be assumed that not the least benefit accruing from clean and careful farming is the reduction in damage caused by insect pests.

Direct measures in the case of the farm may be either (*a*) Preventive, or (*b*) Remedial.

(*a*) *Preventive* measures are of course those which check or destroy insect pests before they have begun to do damage to the crop, and in agriculture the great majority of the known measures come within this category. Their nature

varies so greatly that it is not possible to give instances of all of them, but the following are certain of the more important.

In the first place, the exact time at which a cultural operation is carried out is often of great importance—the date of sowing, for instance, influences the time at which a crop may reach a stage particularly susceptible to a pest; thus the oat, when sown early has ceased to be susceptible to great damage by Frit Fly at the time when the pest appears, but when sown late the crop just reaches its most susceptible stage when the flies are most numerous, and it is therefore seriously damaged, if not destroyed.

Again, in the case of soil pests such as leather jackets (or Crane Fly maggot), if grass land is ploughed shortly before harvest the Crane Flies are unlikely during August or September to lay their eggs in the bare soil and the subsequent crop will escape leather jacket attack. On the other hand, if ploughed in autumn the turf will already contain the eggs of the Crane Fly or newly hatched leather jackets, which will be ready to attack the subsequent crop as soon as it germinates.

A second important measure for preventing attack is to choose a crop or a variety of a crop which is naturally resistant to the attacks of the pest to be feared. Thus in the case of a field infested by wireworms, spring oats would almost certainly suffer, and if a cereal must be chosen, barley, which can be sown later and then grows rapidly, offers a fair chance of success. Even better would be a yet more resistant crop, such as white mustard, which will tend to reduce the numbers of the pest present in the field. The question of the difference in resistance to pests between varieties of the same crop has not yet been studied as thoroughly as the subject deserves, but everyone recognises that certain varieties of, say, wheat or oats do better in one locality than other varieties; and it may generally be assumed that a variety which succeeds in any given district owes some of its success to the fact that it tends to resist the pests of the neighbourhood.

(*b*) *Remedial.*—When an attack is actually in progress the farmer, as compared with the fruit grower, is at a disadvantage since it is seldom a practical proposition to spray or treat a farm crop with insecticides. Under ordinary circumstances the most that can usually be attempted is to assist the crop to contend with the pest and so grow away from the attack, at the same time taking steps to hinder the pest by any means available. Thus, in the case of wireworm attack on winter wheat, which so often shows in early spring, heavy rolling tends to bring the roots into thorough contact with the soil and also to cause the plants to tiller, with the result that the wheat is able to repair the

damage done by the wireworm. Equally, the consolidation of the soil helps to hinder the wireworms in passing from one plant to another and so prevents many from being attacked that would otherwise fall victims. A second measure commonly advised is the application of top dressings to crops to stimulate them into vigorous growth, again with the object of assisting them to repair the damage caused by the pest. This remedy, though sound in theory, is often ineffective owing to the difficulty of applying it sufficiently soon. If an attack is detected in its early stages, before much damage has been done, a top dressing may make the difference between success and failure, but when the damage is already great, the stimulus comes too late to be of much use.

As regards remedial measures aimed more directly at the pest itself, spraying has been effective against such a pest as the Mustard Beetle when applied sufficiently early, but farm insects as a whole are either well protected by their habits against insecticides, or cannot be attacked by means of them on account of the impossibility of moving the necessary machinery among standing crops. The development of insecticides of the dry powder type may alter the position in so far as aphis attacks on peas and beans are concerned, and perhaps in other cases, and their progress is worth watching. Of all insecticides, however, that most needed is an efficient soil insecticide, and it can only be stated here that nothing appears yet to have been discovered which really meets the need.

As regards other direct measures of dealing with farm insects, references will be found in the leaflets to trapping and the use of baits—measures which at present have only a very limited application in agriculture.

Garden and Allotment.

Indirect Measures.—Little need be added to the remarks already made concerning the farm. The garden, however, is usually of small size and therefore clean cultivation and the destruction of rubbish will be less effective unless similar good work is done by adjacent occupiers. There is one additional point which cannot be too strongly emphasised, namely, the folly of attempting to convert grass or rough weedy land into allotments in one season. At least one year, and preferably two, should be devoted to preliminary cleaning crops or even bare fallow, so as to start with land relatively free from soil pests. It is waste of time and money to plant garden crops in a soil full of wireworms, leather jackets, cutworms, and cockchafer grubs.

Direct measures applicable to allotments and gardens cannot easily be classified into those which are preventive and those which are remedial as the two classes merge into one another, and the measures themselves are rather different from those of the farmer or fruitgrower, for on the one hand almost every plant can be given individual attention, while on the other expensive apparatus and chemicals are seldom available. From this it follows that simple measures, dependent not on chemicals or spraying machines, but on the skill of the gardener, are first in importance. For instance, unless the plants are numerous, cabbages, &c., can be kept sufficiently free from White Butterfly caterpillars merely by going over the plants periodically and picking off or squashing the eggs and young caterpillars. Similarly cutworms are best dealt with by searching in the soil close to the plants showing signs of damage. Trapping, if persisted in, will check wireworms, and even slugs, while protection may be given to this class of plants by paper collars, ashes, &c. Such measures depend for their success on the persistence and skill of the user rather than upon the material employed. From this it must not be thought that apparatus and insecticides are not useful, for every gardener should have some form of sprayer, which may vary from a knapsack machine to the cheapest syringe; good work can be done with each and the result depends as much on the judgment and skill of the user as upon the type of sprayer used. So far as insecticides are concerned, poisonous sprays are seldom to be recommended for use in connection with vegetable crops, and therefore the standard insecticides of the fruitgrower need not be considered. The gardener is thus driven to the few simple harmless substances which are available, the most important being soap (preferably soft soap) and paraffin. Most insects which suck, such as Aphides (Green Fly, Black Fly) can be controlled by soap and water alone, or soap, water and paraffin, but as these insecticides are not very powerful the insects must be thoroughly soaked and the applications perhaps repeated at intervals. In the case of paraffin emulsion (paraffin and soap) great care is necessary to see that the paraffin is thoroughly mixed in with the soap and water so that there are no drops of paraffin floating upon the surface of the spray fluid. By far the best way of making this emulsion is to fill the syringe or machine with the mixture and then to squirt it back into the bucket or other vessel in which it was made, repeating the process until a uniform foaming liquid is obtained with no trace of paraffin on the surface. Of other non-poisonous insecticides available to the gardener, pyrethrum may be mentioned. Pyrethrum is sold under various proprietary names as insect powder for killing cockroaches, &c. Any chemist will state which of

the insect powders he sells contains pyrethrum. This insecticide, if fresh, is effective against most insects, and specially against caterpillars, and it may be used in the form of powder or be mixed with soap and water. Formulæ for making the insecticides mentioned above will be found in the various leaflets. As regards soil insecticides, the statements made in regard to farm cultivation apply to a large extent to gardens and allotments, though owing to the fact that more money in proportion to the area can be spent on the latter, heavier dressings of proprietary soil insecticides may sometimes be given with an increased prospect of success. Finally, as regards proprietary insecticides in general, it may be mentioned that the Ministry is precluded from recommending the use of any particular make or brand. There are, however, on the market many proprietary insecticides which are both efficient and easy to handle. Their advantages and disadvantages are known to most gardeners who, from practical tests, can judge best as to when they may be substituted for home-made washes.

J. C. F. FRYER.

10, Whitehall Place,
London, S.W.1.

February, 1926.

THE BEAN APHIS

(*Aphis rumicis*, Linn.).

The Black Aphis, or Black Dolphin, Black Army, Black Blight, &c., as it is variously called, is a common and wide-spread pest of annual occurrence attacking beans of the Field, Longpod, or Windsor class.

All growers of beans will be familiar with the black masses of "blight" which so frequently make their appearance upon the bean plants in early summer. These masses are really a congregation of individuals of *Aphis rumicis*. The winged foundress of the colony is rarely noticed in the first instance: it is only when the family derived from this single visitor has made considerable headway in point of numbers, and the plants in consequence begin to attain a blighted, dirty appearance, that the infestation becomes evident.

Black Aphides should not be confused with thrips—often known as Black Fly. The heavy masses of the aphides clustered together upon the exterior of the plant, which they coat with a sticky mass of "honey-dew" and cast skins, are quite different from the much smaller, long-shaped and active thrips, found for the most part hidden amongst the petals and anthers of flowers.

Infestation by Black Aphides varies in accordance as weather conditions prove adverse or favourable to the insect's propagation, the increase being rapid in times of summer warmth. The damage sustained therefore varies in different seasons, but the loss in total weight of beans throughout the country in any normal year must be very great. As an illustration, in 1920 an attempt was made at the Ministry's Plant Disease Laboratory to ascertain what this loss amounted to on a measured area, and inversely to ascertain what the increase in weight of crop would amount to on an area of the same size, where the plants were kept clean. Two plots of half a rod each were taken, each containing the same number of plants and the conditions as to soil, &c., in each case being as similar as possible. One plot was left entirely to a natural infestation, the other kept free by spraying. The drought which obtained while this experiment was in progress proved very unfavourable for both plots of beans, the crop being poor on the sprayed plot and practically negligible on the infested plot. The pods, however, were picked when ready for table and weighed green, the crop from the sprayed plot proving nearly 4½ times heavier than that from the plot where the Black Aphides were permitted to increase unmolested

Plants Attacked and Nature of Damage.—The list of plants that serve as hosts for the summer generations of Black

Aphides is both diverse and considerable. Amongst them various species of dock, thistle, and poppy are worthy of special mention. Amongst cultivated plants, rhubarb, mangolds grown for seed, turnips, nasturtiums and larkspurs, are occasionally attacked, also runner and French beans.

The damage to the plants by these insects is occasioned principally through the withdrawal of sap and injury to tissue. The stylets, which comprise the sucking apparatus of the insects are driven within the tissues of the plant, the wounds thus caused and the loss of juices thereby extracted combining to render the plants unthrifty. Unchecked, the insects spread to the clusters of young beans, many pods being greatly hindered in development, and even more being prevented from growing at all.

Description and Life-History.—The Black Aphis differs in no fundamental respect from the green forms of aphis or blight found upon fruit trees, roses and other subjects. The fact that this black species frequently seemed to appear almost spontaneously in large numbers gave rise to a belief that it, together with other forms of blight, was born of certain weather conditions, a belief that has not yet become entirely dissipated; the truth being, of course, that aphides have a quite definite life-history just as any other insect has, that is to say, that any particular generation proceeds from its parents and grandparents back through countless generations and is no more capable of proceeding suddenly from nothing than any other living thing, large or small.

The life-history of the Black Aphis is somewhat complicated, as is that of many of the Aphididae.

Very briefly it may be said that towards the late summer the winged females produced by the colonies upon beans and other plants fly away from the beans to the wild euonymus or spindle tree and probably other shrubs. There they produce wingless egg-laying females which pair with winged males bred from aphides still upon the bean. These fertilised females place their eggs in the interstices of the bark—hence no Black Aphides are to be found during the winter, as the colonies on annual plants such as the bean eventually die out. In exceptional cases, however, under mild winter conditions, the sexual egg-laying stage is omitted and generations continue to reproduce themselves as aphides upon docks and the evergreen euonymus. In the spring the eggs present on the euonymus hatch and give rise to female insects which are capable of reproducing rapidly without the male sex and without laying eggs. Amongst the generations so produced appear eventually winged forms which leave the euonymus and produce by the same process generations upon the bean and other plants. These generations consist of both winged and wingless females, the winged forms passing to

1. Bean plant attacked by Bean Aphis.

2. Section of same, enlarged.

other bean plants, &c., to carry on the same method of reproduction. No Black Aphides are therefore present upon euonymus during summer. Males are not produced until the autumnal generations. A Bean Aphis of the spring and summer generations becomes adult in about a week or ten days after birth, according to the weather, and itself gives birth to individuals, so the increase throughout the summer may be very great, a single female being potential for some millions of descendants in a season.

Natural Enemies.—*Aphis rumicis* is subject to a limited control by a species of small ichneumon fly. These minute flies place their eggs within the bodies of the aphides by means of a specialised piercing apparatus. The resulting grubs, after feeding within the bodies of the aphides, use the empty shell of their hosts as cocoons, which are glued down to the plant until such time as the pupal stage is completed and the perfect insects are ready to appear in the open, achieving their freedom by eating their way out. These skins of parasitised aphides are distinguished by their pallor. If intact they contain either the full-fed larva of the parasite or the pupa, but if a round hole is seen it shows that the insect has come to maturity and left, the skin of the aphis then containing nothing but a certain amount of detritus and the discarded pupal envelope.

Methods of Control.—(1) *Garden and Allotment Conditions.*—Wherever spraying is feasible, Black Aphides are readily controlled by the use of almost any good contact insecticide. They may be readily destroyed by a spray containing nicotine, which may be made up as follows:—

Nicotine (95-98 per cent.), ¾ oz.
Soft Soap, ½-1 lb. (according to hardness of water).
Water, 10 gallons.

Nicotine is expensive but it is the best contact insecticide and is worth the cost. For garden work it is convenient to make up a concentrated solution which can be used as required. This can be done as follows:—Dissolve ½ lb. of soft soap in 4 pints of boiling water, allow the solution to cool and then add ¾ oz. (fluid) of 95-98 per cent. nicotine (a photographic measure is convenient for measuring out the nicotine). Stir the mixture very thoroughly and store it in a well-corked bottle. For use take 1 fluid oz. of the concentrated mixture and make it up to 1 pint with soft water. Pure nicotine is very poisonous and must be handled with every care.

Spraying machines are obtainable in many types and sizes, from a hand syringe with a fine spray nozzle to a knapsack sprayer suitable for large areas, and wherever a machine of any make that will give a fine spray is available, the owner

of the average small garden will find the purchase of an ounce of nicotine and a pound of soft soap in the late spring a sound investment. These amounts would probably be found quite sufficient to ensure throughout a season freedom from Black Aphides on beans and green fly on roses and the various subjects attacked, other than the larger fruit trees. When spraying with a hand syringe is undertaken, the mixture used should be kept in a good frothy condition by continuously spraying it back into itself, and the object sought should be to wet thoroughly all the parts of the plants affected, special attention being paid to the undersides of the leaves and stalks.

In the absence of a syringe or sprayer, and where only a small number of plants are to be dealt with, it is possible to get results with a bucket or bowl of contact insecticide and a sponge.

(2) *Paraffin emulsion* might be employed in cases where a supply of nicotine was not readily available.

Paraffin	2 pints.
Soft soap	1 lb.
Water	10 gallons.

Dissolve the soft soap in about a gallon of boiling water, remove the solution from near the fire and while still hot add the paraffin. Churn the mixture very thoroughly by syringing it back into itself. When required for use add soft water to make 10 gallons and mix again thoroughly so as to make sure that there is no free paraffin floating on the surface. Unless the mixing is done very thoroughly, some foliage burning may occur.

(3) *Cultural.*—Many growers sow their garden beans early so that tall, well-developed plants are grown by the time the Black Aphis makes its appearance. Infestation commences at the apex of the plant and spreads downwards, so before this downward spread has got very far, the tips of the plants are pinched out and trodden under foot. It is claimed that this stopping back of the plants not only checks the pest but causes a better development of the bean clusters below. As a preventive measure of control it probably possesses a certain value, but is rarely successful in conferring immunity to the crop from Black Aphides throughout the season.

(4) *Farm or Field Conditions.*—The ease with which Black Aphides may be controlled under garden conditions does not obtain when beans are grown in large quantities, either as a farm or market garden crop, as the area involved would rarely render adequate spraying feasible. Winter beans do not suffer to the same extent as those which are spring sown on account of their early development before the aphides have had time to do a great amount of harm.

Sometimes an attack commences with the infestation, more or less heavy, of a few plants here and there dotted about the field; these centres of infection, being readily observable, can be removed and destroyed with a small expenditure of labour, with the frequent result that little or no further spread of the pest takes place.

CABBAGE CATERPILLARS.

The caterpillars which are so often destructive to cabbages, cauliflowers and similar vegetables, are usually those of White Butterflies (three kinds) or those of the Cabbage Moth. Frequently they are all present together and combine in rendering the crop worthless.

Plants attacked and Nature of Injury.—White Butterfly caterpillars attack all vegetables of the cabbage family, flowering plants such as stocks and, among weeds, Charlock and Shepherd's Purse—in fact almost any plant of the natural order *Cruciferæ* to which all the above mentioned belong. They are also very abundant on garden nasturtium (*Tropæolum*). When the caterpillars are exceptionally numerous and are reduced almost to starvation, they may attempt to subsist on many kinds of plant. "Cabbage White" caterpillars, for instance, have been noted as attacking onions, but this is exceptional, and it is most improbable that the insects could live for long on such a food.

The caterpillars of the Cabbage Moth are more general feeders and will live upon plants of many kinds—both cultivated and wild. In addition to crops of the cabbage tribe, they have also attacked tomatoes, tobacco, lettuce, onions, maize, &c., and they are always troublesome to flowering plants in gardens.

The damage done to all crops, both by White Butterfly caterpillars and those of the Cabbage Moth, is similar. The leaves of the plant are eaten or skeletonised while, in the case of vegetables, the crop is also fouled by excrement. White Butterfly caterpillars perhaps feed more on the outer leaves of cabbages, while those of the Cabbage Moth burrow more into the hearts of the plants, where the results of their feeding are particularly objectionable.

Description and Life-History.—1. *White Butterflies.*—The most destructive species is the Cabbage White (*Pieris brassicae*, L.), which is too familiar to need any description (Fig. 1). The butterflies first appear in spring and early summer and lay their eggs on the leaves of their various food-plants. These eggs are yellow in colour, oval and pointed at one end, and are laid in batches of 20 to 100, being quite

conspicuous on the leaves. In about a fortnight the eggs are hatched and the young caterpillars remain together, forming a small colony. They feed continuously and grow rapidly, always showing a tendency to keep together, so that many caterpillars are usually found on one leaf (Fig. 2). The general colour of these caterpillars is dark bluish or greenish black with a yellow line down the back and yellow along the sides, and they are rather thinly clothed with hairs. After feeding for about a month the caterpillars are full-fed and crawl away to turn to chrysalides, which are greyish or yellowish white in colour with black spots (Fig. 3). They are suspended by the tail and by a silk thread round the middle and are found in a variety of situations—fences, walls or trees in the neighbourhood of cabbage plots being often chosen. In about three weeks (that is to say at the end of July and in August, largely according to the weather) butterflies appear from the chrysalides, eggs are laid, and a further generation of caterpillars is produced. The caterpillars of this second brood feed through August and September and are responsible for very great damage, large areas of cabbage, &c., often being destroyed. In a very favourable season caterpillars may sometimes be found feeding through October into November, and it is possible there may be a partial third generation. As a rule, however, the chrysalides formed by the second brood of caterpillars remain in this stage until the following spring before giving rise to butterflies.

In company with the caterpillars of the Cabbage White Butterfly are often found those of the Small White (*P. rapae*, L.) and the Green-Veined White (*P. napi*, L.). The life-history of these species is similar to that of the Cabbage White. Their eggs are, however, laid singly and not in groups. The caterpillars of these species are green in general coloration and have a peculiar velvety appearance. There are several minor differences between the two species, among which may be mentioned the presence of a narrow yellow line down the back of the caterpillar of the Small White and its absence in the Green-Veined White.

2. *The Cabbage Moth* (*Mamestra brassicae*, L.).—Cabbage Moths are dingy greyish brown in colour with white markings and have the general appearance shown by Fig. 5. They appear towards the end of May and in June, but since they fly only at night they are not often seen, though occasional specimens may be found at rest on palings, tree trunks, or in sheds. Eggs, which are globular in shape, are laid singly on any of their numerous foodplants and from these eggs are hatched small light green caterpillars which feed voraciously on the leaves of the plant. As these caterpillars become older their coloration varies greatly. They may remain light-green as when young, or they may become brown, dark-green, or

Male. Female.

FIG. 1. Cabbage White Butterflies (*Pieris brassicæ*, L.)

(About five-sixth natural size.)

FIG. 2. Caterpillars of Cabbage White Butterfly on a Cabbage leaf.

FIG. 3.

FIG. 4.

FIG. 3.—Caterpillar of Cabbage White Butterfly about to pupate and chrysalis of same.

FIG. 4.—Parasitized caterpillars of White Butterfly and cocoons of the parasite. (A parasite larva is just leaving the lower caterpillar.)

Male.
(Almost natural size.)

Female.
(Almost natural size.)

Chrysalis.

FIG. 5. Cabbage Moth (*Mamestra brassicæ*, L.) and chrysalis of same.

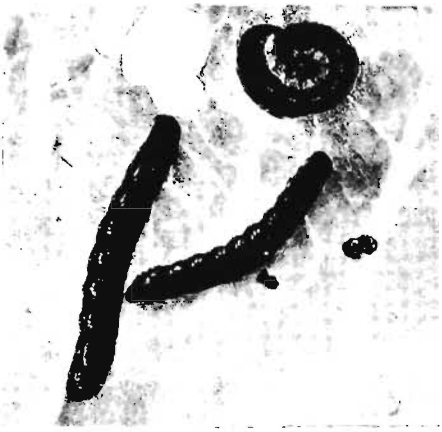

FIG. 6.—Caterpillars of Cabbage Moth.

even black as regards the upper surface, the legs and under surface varying from greenish to yellowish (Fig. 6). The caterpillars feed for a month or five weeks and when full-grown—about $1\frac{1}{4}$ inches in length—they crawl down to the soil into which they burrow, and become shining brown chrysalides (Fig. 5). These chrysalides frequently produce moths during the latter half of summer, which again give rise to a further brood of caterpillars. Caterpillars may be found feeding up to October and, in exceptional instances, on into the winter. Generally, however, some of the chrysalides of the first brood and probably almost all of the second remain as such during the winter and produce moths in the following summer. It is difficult, however, to distinguish the different broods as there is much overlapping, and moths may be found practically from May to September and caterpillars from June to October.

The caterpillars of the Cabbage Moth are often confused with those of the White Butterflies. Owing to their variation it is difficult to give colour differences, but the caterpillars of the moth may be known by the smoothness of the surface and comparative lack of hairs. They have not the velvety appearance of the Small and Green-Veined White caterpillars nor the somewhat conspicuous hairs of the Cabbage White Butterfly.

Natural Enemies.—White Butterflies and the Cabbage Moth are subject to the attacks of various insect parasites and this is notably the case with regard to the former. Caterpillars of the Cabbage White, when full-fed or turning to chrysalides, are frequently noticed with a large number of little yellow cocoons near them, the caterpillars themselves being dying or dead (Fig. 4). These cocoons are made by the larvæ of a small parasite (*Apanteles glomeratus*) which have fed within the body of the caterpillar, and ultimately brought about its destruction. A mistake often made is to suppose that the parasite cocoons are " caterpillar eggs " and they are in consequence destroyed. Caterpillars of course cannot lay eggs. The parasite cocoons should always be left undisturbed since they will produce allies of the greatest value in checking the ravages of White Butterflies.

Methods of Control.—1. *Handpicking.*—In *small* gardens handpicking should not be despised—in a normal year the pests can be kept under control by this measure alone. During the periods when White Butterflies are seen on the wing in some number, crops liable to attack should be examined about once every 7 to 10 days, and all clusters of eggs, and also single eggs, should be crushed. It is more simple to deal with the eggs than with the caterpillars. If any eggs are missed, small holes will be noticed in the leaves and a search should at once be made for the young caterpillars, which

can then be destroyed before the plants have been reduced to skeletons. In the case of the Cabbage Moth searching is less easy, though some can find the eggs without difficulty. The caterpillars also are not difficult to pick off when young. Later, if they have burrowed into the heart of a cabbage they are, of course, inaccessible.

2. *Spraying.*—Since it is better not to use a poisonous spray on green vegetables, the usual caterpillar poisons are not available, and it is necessary to depend on less efficient insecticides which, nevertheless, can be quite satisfactory if applied thoroughly while the caterpillars are still young. The number of sprayings required can only be found by observation. The first spray should be applied as soon as the earliest signs of attack appear, subsequent washings being given if further feeding is observed. In spraying against the caterpillars the work must be done very thoroughly so that the plants are drenched. Further, it is no use waiting in the hope that the attack may not be serious, for by the time it is possible to be certain, the caterpillars will be too large to deal with easily. The following simple solutions have been used with success:—

(*a*)	Soap	$1\frac{1}{2}$-2 oz.
	Water	1 gallon.

If the water is hard, up to 2 oz. of soap will be needed to each gallon of water; with soft water $1\frac{1}{2}$ oz. will usually be enough. The solution should give a good "lather." Disinfectant soaps, perhaps, give better results than ordinary soft or bar soap, but they vary in strength and should be tested on a few plants first to see that no injury is done.

(*b*)	Common salt	2 oz.
	Water	1 gallon.

This is a solution which has long been in use and seems often to have given good results, though failures have also been reported.

In addition to the above simple spray fluids, reference may be made to the insecticides derived from "Tuba" or Derris root. Such insecticides are not (at the time of writing) freely available under the names "Tuba" or "Derris," but they enter into the composition of one or more of the well-known proprietary compounds and, as sold, are stated to be non-poisonous. These insecticides are quite effective against cabbage caterpillars provided they are used before the pests have penetrated to the hearts of the plants. The Ministry is precluded from recommending special makes of proprietary insecticides, but purchasers should have no difficulty in obtaining what they require from any horticultural sundriesman.

3. *Dusting.*—Slaked lime in powder, or lime and soot are sometimes dusted on the plants when damp. There are also

proprietary powder insecticides which are said to have proved effective.

4. Fences, &c., surrounding allotments should be searched for the chrysalides of White Butterflies, which are usually seen without difficulty. When the ground is dug a look-out should be kept for the shining brown chrysalides of the Cabbage Moth, which should also be destroyed.

THE CABBAGE ROOT FLY

(*Chortophila brassicæ*, Bouché).

Introduction.—This fly is one of the most destructive insect pests with which growers of cabbages, cauliflowers and related vegetables have to contend. It is prevalent throughout the greater part of the British Isles and other European countries, and also in Canada and the United States. It belongs to the family *Anthomyidæ*, a very large assemblage of flies, the members of which may be easily mistaken for ordinary house flies, to which they are related.

Plants attacked and Nature of Injury.—The Cabbage Root Fly is an enemy of plants belonging to the cabbage and turnip tribe (natural order *Cruciferæ*); although the heaviest losses are occasioned to cabbages and cauliflowers, other crops, *e.g.* brussels sprouts, broccoli, radishes, turnips and swedes are also attacked. Instances are known of garden stocks (*Matthiola*) being killed by the Cabbage Root Fly, and it by no means confines its attacks to cultivated plants. Among wild crucifers, shepherd's purse, charlock, hedge and black mustard, winter cress and jack-by-the-hedge have been recorded as being infested with the maggots of this insect. Young vegetables suffer more severely from attack than older plants. As a general rule, vegetables grown on a light soil are attacked to a greater extent than those grown on soils of a heavier nature. When a plant is attacked growth is checked, the leaves droop and discolour, the roots are largely destroyed and the plant either dies or its market value is greatly reduced. If an affected plant be pulled up it will be noticed that most of the small lateral roots have been eaten away (Fig. 6), and the maggots are to be found around the main root or in the soil close by. It is in the maggot stage that the insect is injurious, the flies themselves causing no direct harm.

Description and Life-History.—The Fly (Fig. 1) is an ashy-grey insect, not unlike the house fly in general appearance, and measures about ¼-in. long. The first brood of flies

appears at the end of April or beginning of May, according to locality and prevailing climatic conditions; warm dry weather favours its early appearance. The female insect lays her eggs close around the main root of the plants just below the soil surface, and in the course of about 3 to 7 days the young maggots hatch out.

The *Eggs* (Fig. 2) are clearly visible to the naked eye as tiny white cylindrical objects about $\frac{1}{25}$th of an inch long. The young maggots commence injury by gnawing the outer layers of the young roots, and afterwards tunnel into the substance of the larger roots; often the main root is invaded and they may also occasionally extend their attacks to the lower part of the stem.

The *Maggot* (or *Larva*) is white or cream coloured and devoid of legs; at the head end it narrows considerably and carries two minute black mouth-hooks. The body consists of rings or segments which are largest at the tail end, where it appears as if obliquely sliced off (Fig. 3). If the last segment be examined with a good pocket lens a ring of 12 minute projections can be seen, and in the centre are two conspicuous brown dots; these are the spiracles or breathing pores of the maggot. When fully grown (in about three weeks from hatching) the maggot measures nearly $\frac{1}{3}$rd of an inch long; it then usually works its way through the soil a little way from the attacked plant and changes to the *pupa*.

The Puparium (or case which encloses the *pupa*) is $\frac{1}{4}$-in. long and varies from pale to dark reddish brown; its general appearance may be readily gathered from Fig. 4.

There are two generations of flies in the course of the year, and very possibly a third generation may occur in favourable years, though definite proof is needed on this point. The maggots of the late summer remain as pupæ all the winter, and give rise to the first brood of flies of the following year.

Methods of Control.—1. *Tarred Discs.*—Under garden conditions a satisfactory method is that of protecting the plants by means of tarred felt "discs," a measure which has now been successfully employed for some years in Canada and the United States. Experiments* have shown that the "discs" are also reliable for use in this country. The "discs" (Fig. 7) act as a mechanical device preventing the flies from laying their eggs near the roots of the plants. In order to obtain good results, it is desirable that the soil should be in a friable condition to enable the discs to be placed quite flat on the ground. They

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* *Vide* A. D. Imms, *Journal Board of Agriculture*, vol. XXIII, No. 12, March, 1917, pp. 1222, 1224, and XXV, No. 1, April, 1918, pp. 59-61. Further references on the Cabbage Root Fly are also given in this article.

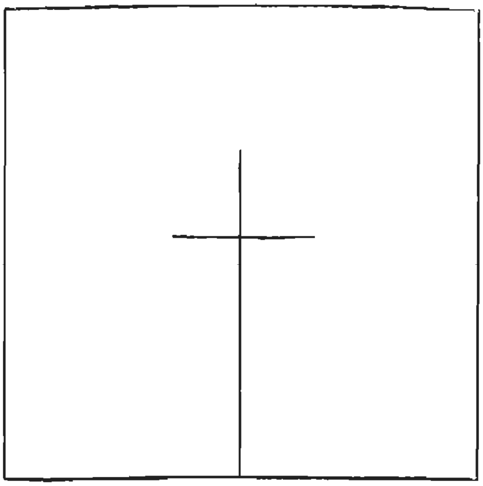

FIG. 7.—Tarred felt "disc," showing how it is cut for use.

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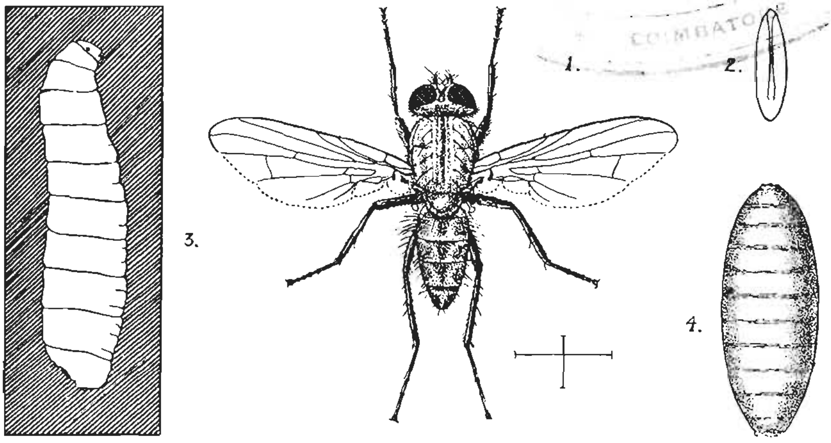

FIG. 1 Fly (after Theobald): the actual size of the insect is indicated by the lines on the right side of the figure: 2—Egg, magnified: 3—Larva, magnified: 4—Puparium, magnified.

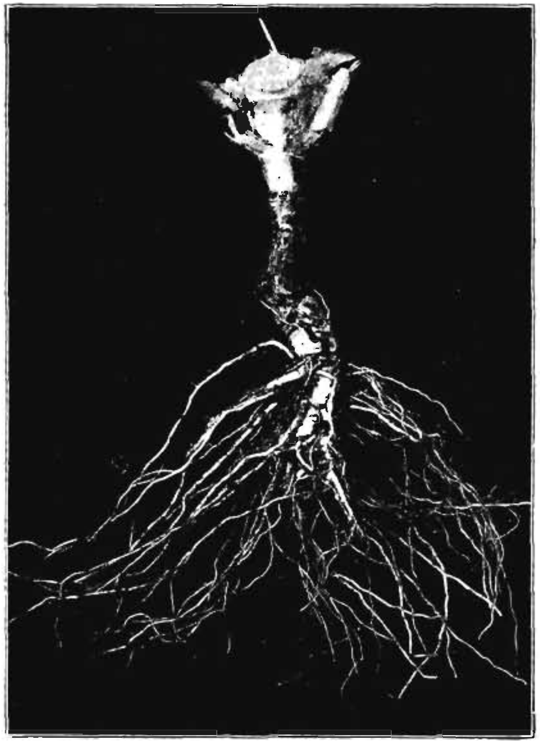

FIG. 5. Healthy unattacked plant showing normal root development.

FIG. 6. Badly attacked plants, with rootlets quite eaten away.

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must be placed round the stems of the plants directly the latter are planted out in the field. Failure to take this precaution often results in the plants becoming infested prior to the discs being applied and the value of the latter is then lost. It is also advantageous if the soil be earthed up slightly around the plants, so as to form a flattened ridge. In the case of vegetables planted out earlier than May, this precaution is not so urgent, but the date of appearance of the flies varies according to the prevailing climatic conditions, and the location of the particular district concerned. The main function of the disc is to act as a mechanical device to prevent flies from laying their eggs in the usual position, close round the plants. It is, furthermore, important to keep the surface of the discs free from soil, otherwise the insect will deposit its eggs thereon, and the young maggots will gain access to the protected plants. The application is extremely simple, and can, if necessary, be undertaken by children. If the discs are placed carefully on the plants no further attention as a rule is necessary. Once the plants have made good growth they have been tided over the most vulnerable period, and the soil can be earthed up over the discs, as the latter are then no longer necessary.

NOTE.--To place a disc in position open the main slit and lift up the two flaps in the centre, slip it round the stem and press down the flaps close around the latter. When properly applied the disc should be perfectly flat on the soil. The discs can now be obtained from most Horticultural sundriesmen.

2. *Creosote.**—As a preventive creosote, applied around the junction of the stem of the plant with the soil, has given good results. Dry earth (not sand) or precipitated chalk or other absorbent must be used as a base for the creosote, at the rate of 1 oz. creosote to 3 lb. chalk. (This quantity will dress rather more than a rod.)

To prepare—the chalk may be placed in a convenient receptacle and the creosote added slowly, the chalk being stirred the while.

This mixture should be dusted round the plants after they are set out in the spring and repeated at two or three fortnightly intervals.

3. *Corrosive Sublimate.*—In America a solution of corrosive sublimate has been used with success at the rate of 1 oz. to 10 gallons of water. On account of the intensely poisonous nature of corrosive sublimate (Bichloride of Mercury) the question of this method finding favour (or being desirable) in this country is open to doubt. The method should be avoided in gardens and allotments, but it might be tested by commercial growers with a large acreage.

* For further information *see* "Control of Maggots attacking the Roots of Vegetables," *Journal Ministry of Agriculture*, June, 1922.

To prepare—the sublimate should be dissolved first in hot water and the amount made up to 10 gallons afterwards. This should be given in four applications (each of 4 to 6 fl. oz. to a plant) at intervals of a week or ten days after planting out.

4. *Carbolic Acid Emulsion.*—Carbolic acid emulsion has also been used in America for destroying the eggs or for killing the maggots, but the results have not been uniformly satisfactory. The formula for the carbolic acid emulsion is 1 lb. of hard soap or 1 quart of soft soap, dissolved in one gallon of boiling water, into which 1 pint of crude carbolic acid is poured. This should be well stirred till an emulsion is formed. For use, one part of the emulsion should be diluted with thirty-five to forty equal parts of water. This solution may be applied with a can or spraying machine from which the nozzle has been removed, so as to saturate the soil nearest the roots of the plants.

5. *Cut Stumps.*—Whenever the maggots are prevalent the custom of leaving the cut stumps in the soil should be abandoned. These, and all infested plants, should be pulled up and burned. By this means large numbers of maggots are destroyed which otherwise would have given rise to fresh generations of the insect.

6. *Cultivation.*—In autumn and winter, digging over the soil exposes large numbers of the puparia to the attacks of insectivorous birds.

7. *Rotation.*—Where the attack has been bad, neither cabbages nor any similar crop should follow immediately; all weeds, which may serve as food plants for the cabbage maggot, should be destroyed.

8. *Sheltering of Seedlings.*—Sheltering the seed beds with frames covered with cheese cloth is of value. It allows of sound healthy plants being removed for transplanting to permanent quarters.

Natural Enemies.—The puparia of the Cabbage Root Fly are subject to the attacks of several insect enemies. The grubs and adults of two small rove beetles, *Aleochara bilineata* and *A. nitida*, destroy considerable numbers. An insect of the Gall-fly tribe known as *Cothonaspis rapæ* is also of some value as its grubs (or larvæ) similarly destroy the puparia of the Root Fly. Under normal conditions probably quite 20 per cent. of the puparia are destroyed by various insect agencies. Any small black rove beetles met with in the soil, among plants of the cabbage tribe, should in no circumstances be destroyed.

THE CARROT FLY

(*Psila rosæ*, Fab.).

This fly occurs throughout Europe, in the United States and in Canada. In Britain it is specially a pest of gardens and market gardens, in which carrots are grown from year to year, with the result that the insects are never without their favourite foodplant. Under the farm cultivation practised in the east of England, for instance, the carrot fly is much less prevalent, probably because fields are only sown with carrots (or parsnips) at intervals. The prevalence of the fly is more a feature in districts of light soil than in those where the soil is heavy. This may be due to carrots being eminently a light soil crop and one that is not grown to any great extent on soils of a heavy nature.

Plants Attacked and Nature of Damage.—Although other plants, such as celery, parsley and parsnip are attacked, it is as an enemy of carrots that the fly is chiefly important. The larvæ or maggots bore into and feed upon the roots, causing them to become brown or "rusty" and finally rotten. In some cases of early attack the growth of the small roots is entirely checked. Carrots grown for "bunching" or pulling early are not often materially injured, as the attack does not as a rule begin until the end of May; the value of these early roots is, however, sometimes depreciated by the rusty spots made by the maggots. On the other hand, carrots that are dug late for storing are frequently very seriously damaged: they rot in the clamps and stores and are rendered unsaleable through the depredations of the Carrot Fly larvæ. Carrots badly attacked by this pest sometimes have deep cracks in which the larvæ are found, such cracks frequently extending to the centre of the roots, causing them to rot. These cracks are for the most part across the carrot and should not be confused with the big vertical cracks which frequently split a proportion of the roots from top to bottom and arise from a different cause. In bad cases of infestation decay is often hastened by the attacks of slugs, millepedes and woodlice ("Slaters"). The maggots of the Carrot Fly frequently remain in the roots after they have been stored, and continue to injure them for some time. It has been noticed that the Carrot Fly is more injurious in dry seasons, when the growth of the plants is not so luxuriant and rapid as when moisture is plentiful.

Carrots that are attacked by the maggots can easily be recognised by the appearance of the foliage: in the early stages of infestation, when there are but few larvæ in the roots, the leaves turn reddish, while the tops of badly attacked plants turn yellow and wither away. On pulling

up a carrot which shows these indications of attack, the maggots will often be noticed protruding from holes in the root.

Description and Life-History.—The Carrot Fly is shiny black or dark greenish-black in colour and about one fifth of an inch in length, with a wing expanse of nearly half an inch. The wings are iridescent. The flies appear during May or the early part of June and, when the carrot roots have attained a fair size, lay eggs close to them, just below the surface of the ground.

These eggs are white, elongate and exceedingly small (about one-fiftieth of an inch in length). They are laid singly or in clusters, the female usually choosing small cracks in the soil in which to deposit them. When hatched, the maggot, which at first is colourless and transparent, works its way through the soil to the lower part of the carrot, where it gains an entry, and then tunnels upwards, making frequent holes to the outside. As the maggot grows it becomes yellowish in colour and, like all fly larvæ, is without legs (*see* Fig. 2). When full-fed, the maggots, which are about $\frac{1}{4}$ inch in length, leave the root and pupate in the soil, the winter being passed in the pupal state. The puparium, or pupa case, is light brown in colour.

According to Smith*, there are two generations in the year, but the second is only partial, as many of the pupæ of the first brood do not emerge until the following spring. The flies of the second brood usually emerge about two months after those of the first.

Preventive and Remedial Measures.—*Farm.*—1. Under farm conditions the best means of ensuring freedom from Carrot Fly attack is to avoid growing carrots as an agricultural crop too frequently. It is advisable so to arrange the rotation that a field of the current year should not be in close proximity to one carrying carrots or parsnips the previous year.

Garden and Market Garden.—2. When it is noticed that the tops of carrots change colour prematurely and the presence of the pest is confirmed by examination of the roots, the portions of the rows infested should be forked up and destroyed.

3. As a preventive measure, spraying with paraffin emulsion is sometimes recommended. A suitable emulsion may be made as follows:—Dissolve 1 lb. of soft soap in 1 gallon of boiling water, and while still hot add 2 pints of paraffin and churn the mixture thoroughly. When required for use

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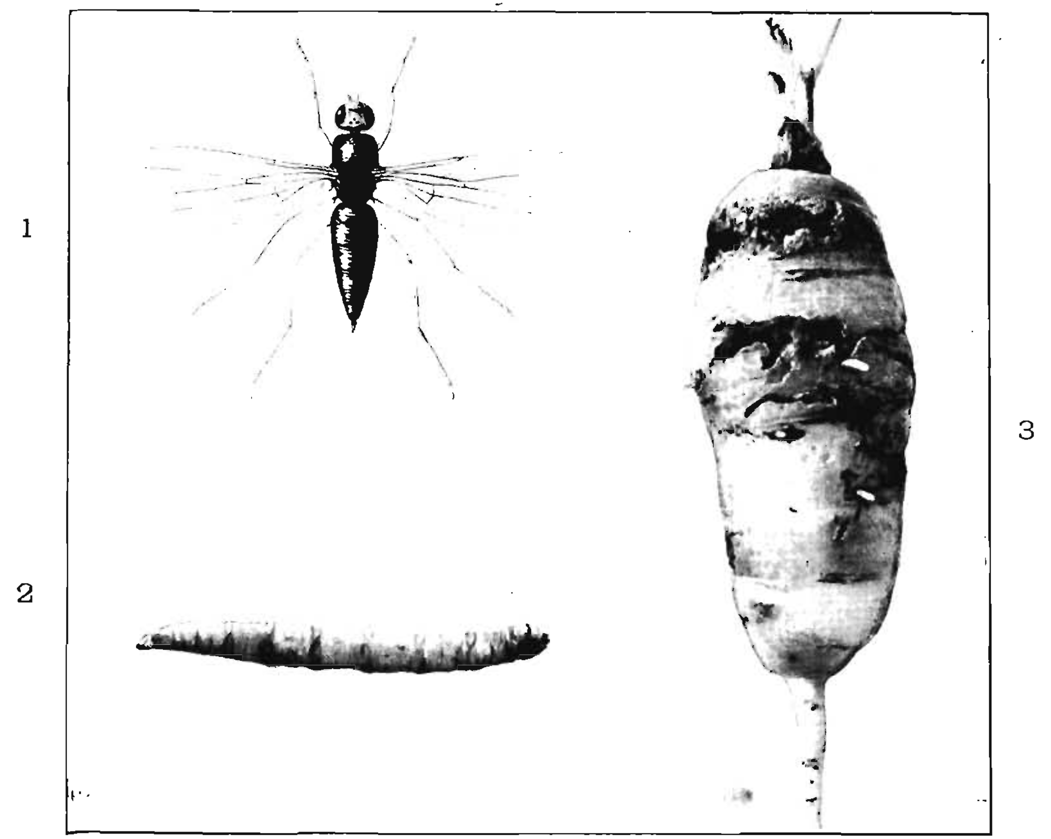
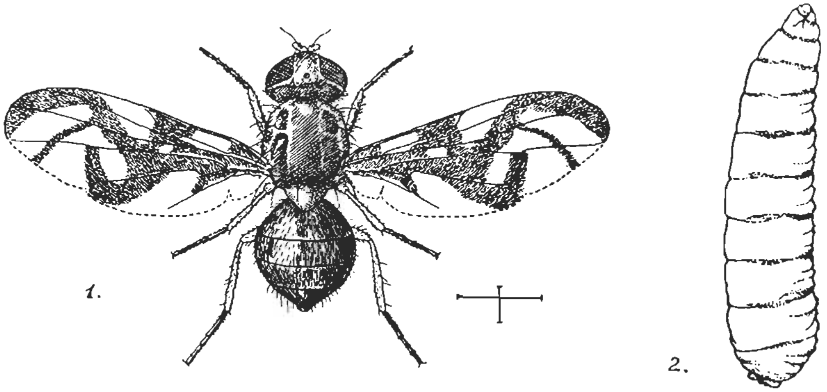
* Insect Pests of the Horticulturist. Onion, Carrot and Celery Flies, p. 65.



1. Carrot Fly. 2. Larva. 3. Attacked Carrot.

11--26



1. Fly magnified. 2. Larva magnified. Lines show natural size of Fly.

Celery leaf showing blister-like patches.

11—27

one gallon of this mixture should be added to 9 gallons of water. Rain water or water that is not very hard should be used. The carrots should be sprayed shortly before, and again just after, thinning. Smith recommends a mixture of green tar-oil and precipitated chalk, in the proportion of one part of the oil to 100 parts of the chalk. If sand is used instead of chalk, the oil does not mix well with it, and is apt to damage the plants.

4. Pressing the earth close round the stems tends to prevent the flies from egg-laying. This may be done immediately after the plants are singled, on large holdings, by men or boys treading both sides of the rows.

5. It is a matter of common observation that carrots that have sprung up singly on paths or the like, from seed accidentally dropped, are seldom attacked. From this it may be assumed that the operation of thinning is, in many instances, a predisposing cause of attack, as the smell of the pulled carrots attracts the flies, and the disturbance of the ground leaves many convenient cracks for the females to lay their eggs in. This has led some growers to sow carrot seed very thinly, in order to avoid the necessity of thinning the crop.

6. In all cases young carrot plants removed during the operation of thinning should not be left to litter the ground, but should be taken away as soon as possible. Where the area under carrots permits, thinning may advantageously be done in the evening after sundown, when the flies are not active—the thinnings being removed at once.

7. In small gardens heavy watering of the crop after thinning may be undertaken to consolidate the soil, and so ward off attack.

8. Where carrots have been stored in earth, measures should be taken so that any puparia, or maggots that have left the roots to pupate, may be destroyed.

9. In localities where the fly is very prevalent a supply of carrots can usually be maintained by the adoption of the following measures:—(a) For early use, sow such early varieties as French Forcing in a sheltered position as soon as the soil and weather permit in February and March. (b) Defer the main crop sowing until mid-July, and choose the Early Horn variety, which will grow sufficiently large for storing for winter use.

THE CELERY FLY

(*Acidia heraclei*, Linné).

The Celery Fly (*Acidia heraclei*, formerly known as *Tephritis onopordinis*) is a well-known pest in the British Isles and the continent of Europe generally. The larvæ mine in the leaves of

celery and parsnips and are frequently the cause of a great reduction in the value of the crop. The attack may commence in April or early in May, and last, in mild seasons, until as late as the beginning of December.

Nature of Injury.—The larvæ live upon the juicy substance between the upper and lower skins of the leaf, making blister-like patches, which are at first pale but later become brown; the leaf soon contracts, and after a short period shrivels up and becomes utterly valueless to the plant. In consequence of the loss of the leaves, the celery stalks and stems cannot grow and fill out properly, while in bad attacks the plant is killed or the celery is small, green, and of a bitter flavour.

Parsnips suffer in the same way, and when badly attacked the roots are small and generally of a bad shape.

Description.—The fly (Fig. 1) is only about one-eighth of an inch in length, with a wing expanse of nearly half an inch. It is tawny brown in colour, with the under part of the body lighter coloured. The wings are iridescent, with oblique brownish or rust-coloured bands and transparent spots. The eyes are deep green in colour, and the legs dark yellow, clothed with short black hairs. When the fly is sitting or running upon the plants its wings are held in an upright position and frequently waved up and down.

The larva (Fig. 2) has no legs; it is white or very light green in colour, with the dark line of the gut visible through the skin. In shape it is rather stout, pointed at the head and squared off at the tail, where there are two black tubercles.

The puparium is oval, of a light yellow colour, much wrinkled, and about one-eighth of an inch in length.

Life-History.—Many eggs are laid by one female fly, the underside of a leaf usually being chosen and each egg placed singly within the tissues of the leaf, just beneath the skin or cuticle. The eggs hatch in about six days, and the young larvæ at once bury themselves in the leaf tissues and form mines within them. In about 14 days the larva changes to a pupa inside a pupa-case or puparium, either remaining in the leaf or falling to the ground. The fly hatches out in a few days, and there are several broods or generations in the course of the summer. The last generation remain in the puparium stage in the earth and also on pieces of leaf and stalk throughout the winter, the fly appearing the following April.

Methods of Control.—1. When possible it is wise to avoid growing successive crops of celery in close proximity to each other.

2. Theobald* advises the protection of the seedling plants during sunny weather by means of muslin screens. The young seedlings are often attacked by the first brood of the fly before they are planted out, but, if protected at this stage, they usually escape subsequently.

3. When a few leaves only in a bed are noticed to be attacked they should be picked off and burnt.

4. A mixture of three parts soot and one part lime dusted upon the leaves from April onwards is reported to be of service in preventing the female fly from laying her eggs. Success is said also to have been obtained by the use of deterrent sprays, which, however, must be applied frequently from the time when the plants are in the seedling stage. They are of no use for killing the larvæ within the mines. Paraffin emulsion has been recommended as a good deterrent, and a suitable formula will be found on p. 26.

5. It is desirable to force rapid leaf-growth where there is a bad attack. Applications of nitrate of soda mixed with a little agricultural salt, and frequent and heavy watering will effect this.

6. Theobald* records excellent results in killing the larvæ obtained by spraying infested celery with a solution containing one part nicotine (98 per cent.) in 200 parts water with sufficient soap to make a lather. This formula, however, requires about 8 ozs. nicotine to make 10 gallons of spray fluid and would be too expensive to have a wide application. A trial might be given to a more dilute solution such as:—nicotine (98 per cent.) 1 oz., soft soap ½ lb. and water 10 gallons.

7. Directly any celery or parsnips have been dug, every particle of foliage and stem should be collected and burnt. If it is merely put in bulk upon compost heaps, or mixens, not in active fermentation, it is most probable that the puparia will be carried out with manure for celery or parsnips, or other crops grown near, and the flies will issue in due course. In cases where the foliage and stem cannot be conveniently burnt they should be buried deeply.

* Theobald. Journal South Eastern Agricultural College, Wye, Kent, 1913, pp. 296, 297.

CHAFER BEETLES.

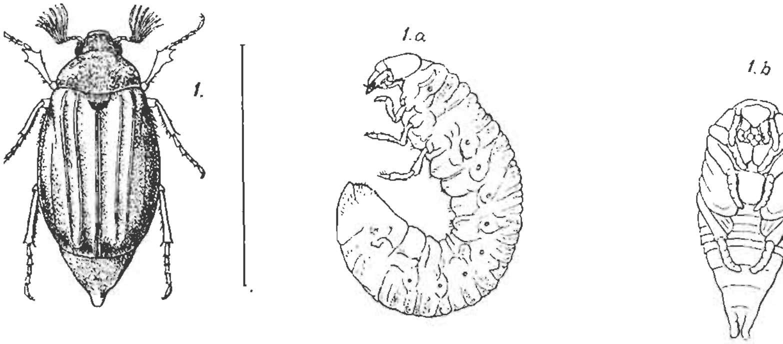


FIG. 1.—The Cockchafer (*Melolontha vulgaris*).
1. Perfect insect. 1*a*. Larva. 1*b*. Pupa.

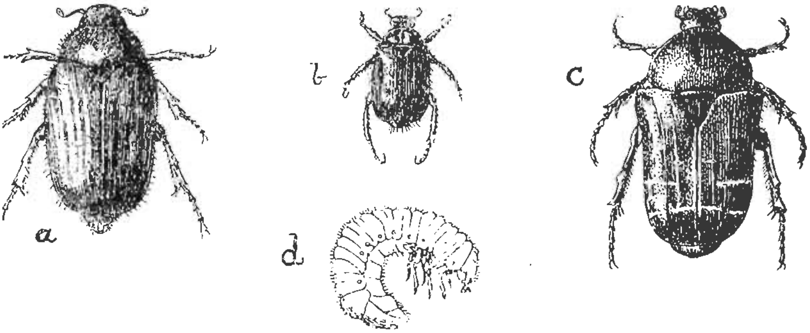


FIG. 2.—Other Chafers.
a. The Summer-chafer (*Rhizotrogus solstitialis*). *b*. The Garden-chafer (*Phyllopertha horticola*). *c*. The Green Rose-chafer (*Cetonia aurata*). *d*. Larva of the Garden-chafer. Slightly magnified.

Distribution and Damage.—Chafer beetles of the species dealt with in this leaflet occur in most parts of the country, but are perhaps specially abundant in the neighbourhood of woods and heaths where the soil is light and well drained. The beetles themselves usually appear in swarms and do much damage by feeding on the leaves of fruit and forest trees and shrubs, which may in a day or two be completely stripped. The grubs—sometimes known as White Grubs—which live in the soil are even more harmful than the adults, attacking the roots of almost all crops in farms and gardens, including the woody roots of trees and shrubs. On farms the chief injury is done to pasture and crops grown on newly-ploughed grass, or on land which has previously been foul. Grass-land suffers most from the attacks of the Garden and Summer Chafers which seem to be specially injurious to the

hill pastures of the West of England and the sandy soils (breck) of the East. Cockchafers prefer well wooded country, and attacks by their grubs are naturally more to be expected in such neighbourhoods.

Horticultural crops suffer under similar circumstances to those on farms but the loss is greater owing to the fact that the crop attacked is perennial. For instance, in laying down land to strawberries, particularly where the land has been foul or rough, it should be ascertained if white grubs are present. If they are and they cannot be disposed of prior to planting, it is better to delay a year and to grow some annual crop such as mustard, beans, or potatoes, which, if attacked, will suffer less injury and cause a smaller financial loss. The same remarks apply to the selection of sites for nursery beds whether of fruit or forest trees.

As in the case of all soil pests it is better to take preventive measures prior to the planting of a crop rather than to attempt the difficult problem of dealing with an attack when in progress and when, usually, much damage has already been done.

(1) **The Cockchafer** (*Melolontha vulgaris*).

Description.—The Large Chafer, usually called the Cockchafer (Fig. 1, 1) is often an inch in length, with head and front portion of the body black, the wing-cases (elytra) being reddish-brown, hairy and with five raised lines on each. Along each side of the abdomen are five white triangular marks. The abdomen ends in a prolongation, downwardly curved, and not covered by the elytra. The end joints of the antennæ form a kind of club. Time of appearance, May-June.

The grub (Fig. 1, 1*a*) is thick, fleshy and dirty-white, the tail end of the body being swollen and in colour a dark purple brown. The head is large and brown, the mouth being armed with strong mandibles. There are three pairs of jointed legs on the front of the body. These white grubs lie with their bodies bent, and, although sluggish when taken out of the soil, are comparatively active when in it. Their length when full-grown is about 1½ inches.

The pupa, shaped as in Fig. 1, 1*b*, is white in colour, soft and easily injured, and lies in a large definite cell rather deep in the soil.

Life-History.—The beetles fly in the evening, resting sluggishly during the day on trees. After pairing the female burrows into the earth and lays her eggs, 12 to 30 at each laying, and up to 70 in all. After five to six weeks the larvæ hatch. No great damage is done till the next summer when the grubs gnaw the roots of grass, agricultural plants and seedling trees, the feeding being continued during a third and a fourth summer. The grubs then become pupæ in the soil and the beetles appear above the ground the following May.

(2) **The Summer Chafer** (*Rhizotrogus solstitialis*).

Description.—The Summer Chafer (Fig. 2, *a*) which appears in June and July is smaller than the Cockchafer, being about two-thirds of an inch long but has the appearance of being only about half the size of the larger insect. The colour varies from light reddish-brown to dull yellow and fresh specimens are distinctly hairy. The wing covers have *four* raised lines as opposed to *five* in the Cockchafer.

*The grub is similar in appearance to that of the Cockchafer, but proportionately smaller in the full-fed examples. Superficially, and without the aid of a microscope, a Summer Chafer grub is difficult to distinguish from a young Cockchafer grub of the same size.

Life-History.—The Summer Chafer has a similar life-history to the Cockchafer, but the grubs are more destructive to agricultural plants than to young trees. The beetles rest in the daytime and fly in the evening, when they sometimes appear in thousands. There is no complete agreement as to the length of the life-cycle, but very probably a generation can be completed in one year. The swarming of the beetles lasts for only a few weeks, and may, under similar weather conditions, be expected at the same time in the next year.

(3) **The Garden Chafer** (*Phyllopertha horticola*).

Description.—The Garden Chafer (Fig. 2, *b*) varies from one-third to half an inch in length, appears to be about half the size of the Summer Chafer, and is the smallest of the three destructive species of Chafer. The front part of the body or thorax is of a metallic greenish hue and the wing-cases of a reddish-brown colour. The male is very hairy. The adults appear in June.

The grub (Fig. 2, *d*) is similar in appearance to both of the foregoing, but again is proportionately smaller.

Life-History.—This beetle flies in the bright sunshine and often in great swarms. The mature insects devour leaves of

* **Technical Note.**—The *larvæ* of the Lamellicorns dealt with in this Leaflet may be determined by the following microscopic differences :—

(1) In the first place care should be taken not to confuse them with the larvæ of such Scarabæids as *Aphodius* spp. and *Geotrupes* spp., in which the lobes of the maxillæ are connate, in contradistinction to the free lobes of the Melolonthids and Rutelids.

(2) In *Melolontha vulgaris* an area on the undersides of the mandibles where the light and dark parts unite is distinctly granulated.

(3) In *Rhizotrogus solstitialis* the whole under surface of the mandibles is very minutely granulated (hardly visible).

(4) In *Phyllopertha horticola* there is a pale striated oval area—rather like a file—on the underside of the mandibles.

(5) In *Cetonia aurata* the larvæ resemble that of *Melolontha vulgaris* but may be distinguished by a large rusty spot on each side of the prothoracic segment. The body is also hirsute, the hairs being arranged in transverse rows.

trees, notably fruit trees, and also are destructive to peas and garden plants such as roses. Young apple and pear fruits are also attacked. The female beetles lay eggs in the soil, and the resulting grubs feed upon the roots of grass and other plants. As in the case of other chafers, the grubs turn to pupæ in the soil, from which the beetles subsequently emerge. There is one generation each year.

(4) The Green Rose Chafer (*Cetonia aurata*).

Description.—This beetle (Fig. 2, *c*) measures two-thirds of an inch in length, being somewhat larger in size than the Summer Chafer, but readily distinguished by its beautiful metallic golden green colour, the wing covers being marked with white specks. It occurs in May and June, but is of much less economic importance than the three foregoing species, and is chiefly harmful in gardens, especially to rose blooms.

Life-History.—The eggs are laid in the ground, but the grubs have also been taken from rotting wood of tree stumps. Pupation takes place in an earthen cell. Two or more years may be required to complete the life-cycle.

Methods of Control.—1. Chafer grubs are susceptible to naphthalene and to insecticides containing this substance.

Naphthalene is a by-product in gas-making, and can sometimes be obtained cheaply in a crude or semi-refined form from a neighbouring gasworks. It may also be obtained through manufacturers of insecticides.

In the case of attacks on grass land naphthalene may be applied broadcast to the affected areas at about the rate of 2 cwt. per acre. The dressing may be given in either autumn or spring, and is most effective when followed by rain, which carries the insecticide into the soil.

When the grubs are working at the roots of raspberry canes, strawberries, &c., naphthalene may be worked into the soil between the rows near the roots.

2. If infested grass-land is being converted into arable, both a fine pulverisation of the soil and a close consolidation of it by rolling have the effect of destroying fleshy, easily injured grubs, while this treatment also assists the subsequent crop to grow away from the attack. Poultry turned on the land when it is ploughed will greatly reduce the numbers of the grubs. Pigs have been found equally effective.

3. In the case of new allotments in which the large grubs of the cockchafer are discovered it should prove possible to control the insects sufficiently by hand picking when the land is dug.

4. It is said that trapping the larvæ has also been resorted to with marked success. For this purpose, pieces of turf from

eight to twelve inches broad and six to eight inches thick are laid, with the grass downward, on the surface of the ground. The larvæ collect beneath the turf. Heaps of turf, humus, dung, &c., may also be employed as larval traps.

5. When the beetles of the garden chafer are attacking fruit trees a lead arsenate spray (lead arsenate paste 1 lb., water 25 gallons) is worth trial, but the insecticide must be applied at once as the beetles injure the trees very quickly. In the case of a few trees it may prove possible to collect the beetles by jarring the branches over a sheet. The latter method is practised on the Continent for the control of all chafer beetles.

6. The rook, starling, green plover, and the black-headed and common gulls devour large numbers of white and other grubs. The two birds last mentioned often occur far inland, and may be seen following the plough and greedily picking up any larvæ that are thrown up. Moles also hunt in the ground for the grubs. The adult chafers are eaten in large numbers by owls, night-jars and bats.

COLORADO BEETLE

(*Leptinotarsa decemlineata*, Say.).

This beetle—notorious as a potato pest—was first discovered in the west of the United States where it was living upon a wild plant related to the potato. About the year 1850 it was first noted on potatoes and by 1874 it had spread eastwards across the continent of America to the Atlantic and also northward into Canada. On several occasions it has been carried by shipping to Europe and has even established small colonies which up to the present have been stamped out by the use of drastic measures—as, for instance, at Tilbury in 1901-1902. In 1922 the beetle was discovered in France in the neighbourhood of Bordeaux, about 100 square miles being infested. This is the most serious outbreak which has yet occurred in Europe and it renders great vigilance advisable on the part of potato growers in order to prevent a similar occurrence in Britain.

Description and Life-History.—The adult beetles (Fig. 1) are about half-an-inch in length, yellow in colour with five longitudinal black lines on each wing-case—ten lines in all. The winter is spent under the soil, usually about ten inches below the surface, but less frequently the beetles winter among

rubbish. When the weather becomes warm in spring or early summer they come out, pair, and the females fly in search of potato plants, tomatoes or such related weeds as deadly nightshade, upon which to feed and lay their eggs. As the beetles may become active before the majority of the potato crops are above ground, the insects may be forced to fly considerable distances to find their food. On reaching potato plants they feed on the foliage (Fig. 2. A.) and also lay eggs —yellow and oval in shape—on the undersides of the leaves (Fig. 2. B.). The eggs are laid in clusters of from ten to forty and in a week or longer, according to the weather, hatch into red-brown larvæ or grubs (with six legs but no wings) which eat the potato leaves and grow rapidly, becoming paler in colour, varying from orange to brick-red, and noticeably spotted with black (Fig. 2. C.). The grubs feed for three weeks, probably longer if the weather is cold, and, if numerous, strip the plants of their foliage and even eat the haulm to the ground; they then bury themselves in the soil, where they change to pupæ and subsequently to adult beetles. In accordance with the climate there may be one, two or even three generations in the summer. On the approach of cold weather in the autumn the beetles bury themselves in the soil and await the following spring.

The Risk to Britain.—Taking into account the records of the behaviour of the Colorado Beetle in the outbreaks which have already occurred in Europe, it seems only too likely that the insect would find the climate of England congenial and that it would in consequence cause great loss, the nature of which is evident, since the potato plant devoid of foliage or eaten to the ground cannot produce a crop.

As regards the means by which the insects may be expected to reach our shores, it is fairly certain that they cannot fly from Bordeaux, still less from America, and they must therefore come on board ship. In this connection it is obviously the adult beetles that are to be feared, since they can fly on to vessels or crawl into packages awaiting shipment, and on arrival at an English port they can again fly, if necessary for several miles, until they meet with food. Spring or early summer is the most dangerous period, for the beetle is then most likely to wander and a single female will be sufficient to start an outbreak. On the other hand, beetles arriving in England in autumn will be mainly infertile, must wait until the spring, and then the two sexes must meet before breeding can take place, a coincidence which is evidently very unlikely to occur. Still more remote are risks from the introduction of larvæ, since for all practical purposes they may be regarded as incapable of travelling for more than a few yards and must therefore be actually placed among growing potato crops if

they are to live. The same applies with equal force to eggs. The practical application of this is that no matter what regulations are made to guard against the importation of the Colorado Beetle, some risk must still remain, since no precautions can prevent a beetle from flying on to a ship in America or France and flying off again when the vessel reaches an English port. With the establishment of a colony of the pest so near as Bordeaux this risk is very definite and,

THE COLORADO BEETLE.
FIG. 1.—Beetle. FIG. 2.—Damaged potato foliage showing:—
(A) Beetle, (B) eggs, (C) larva.

unless the French are successful in their attempts at eradication, it is by no means unlikely that England will have to deal with an outbreak before many years are past.

Prevention and Control.—Such legislative measures as are possible have been, and will be taken to reduce the chances of the *importation* of Colorado Beetles and, as these measures must vary from time to time, the Ministry will issue special notifications. If an outbreak is discovered drastic measures will again be necessary in attempting to extirpate the pest and will probably be successful provided they are taken in time. It will, however, be exceedingly difficult to stamp out a colony after it has been present for a year or more and, if this should occur, the insect will probably have to be numbered among our regular potato pests. Growers will then find that they can only obtain a crop if they spray it twice during the summer with lead arsenate or other poisonous wash, and they can in consequence estimate the loss annually as the cost of two spray applications—a severe addition to the expenses of a crop in any case costly to grow.

It cannot therefore be urged too strongly that growers, in their own interest as well as in that of the country, should keep a careful watch for any suspicious pests on their potato crops, and notably for yellow and black insects feeding upon the foliage. By notifying the Ministry at once they may be the means of preventing the establishment in England of perhaps the most serious insect enemy of the potato known up to the present.

Legislation.—The Colorado Beetle was made the subject of legislation in 1877 by the Destructive Insects Act, and it is included among the insects scheduled under the Destructive Insects and Pests Order of 1922. This Order renders it illegal to land, sell or offer for sale in England and Wales any living specimen of the beetle, without the written permission of the Ministry. Owing to the appearance of the pest in 1922, in the neighbourhood of Bordeaux, the importation of living plants or vegetables into this country from a certain area in southern France is prohibited by the Colorado Beetle Order of 1922. Copies of the above mentioned Orders may be obtained on application to the Ministry.

DADDY LONGLEGS OR CRANE FLIES

(*Tipula oleracea*, Linné, *T. paludosa*, Meigen, &c.).

Leather jackets, the larvæ or grub of the large, awkward, long-legged flies known familiarly as "Daddy Longlegs," have been recognised for a long time past as very destructive farm and garden pests throughout Europe and North America. They attack indiscriminately all kinds of farm and garden crops. It is said that in the aggregate they do most damage to grassland, but the results of their attack are most conspicuous on cereals in the spring and early summer.

Tipula oleracea and *T. paludosa* are to be found throughout the British Isles, but the latter is the more common species; the larvæ of these two constitute the great majority of the large, destructive "leather jackets." There are several other species which are also injurious, including *Tipula lateralis*, which is often common in, and destructive to, grasslands; and some species of *Pachyrhina*, which often attack garden crops; it appears, however, that these, like the two first-named species, will at times attack any kind of crop.

Nature of Injuries.—The grubs feed just below the surface of the ground, on, or in, the roots of the plants attacked, but they will also, especially at night or on dull, damp days, attack plants above ground. In large roots or tubers they often work into the interior and become completely hidden. In cereal crops the grain may be attacked before or after germination and the contents more or less completely eaten out; the root and stem below ground may be eaten away, and the stem or blade cut off above ground. The whole plant may be completely killed, and then large bare patches will appear in grass lands or cornfields, or even the whole crop on a field be destroyed.

Description and Life-History.—The life-history of the most common Crane Fly (*Tipula paludosa*)* is as follows:—The small, oval, black eggs are laid by the female soon after emergence on, or just under, the surface of the ground, and as the flies continue to emerge over a long period the egg-laying may take place from June to September. One female may lay as many as 300 or more eggs. The eggs hatch in about fourteen days and the young larvæ are very susceptible to drought and sunlight, dying off quickly if kept in a dry soil or exposed to strong sunlight. The larval stage lasts at least nine months and may last much longer; under experimental conditions and with limited food, larvæ have been

* Rennie, J.—Annals of Applied Biology, Vol. II, pp. 235-240 (April, 1916), and Vol. III, pp. 116-137 (January, 1917).

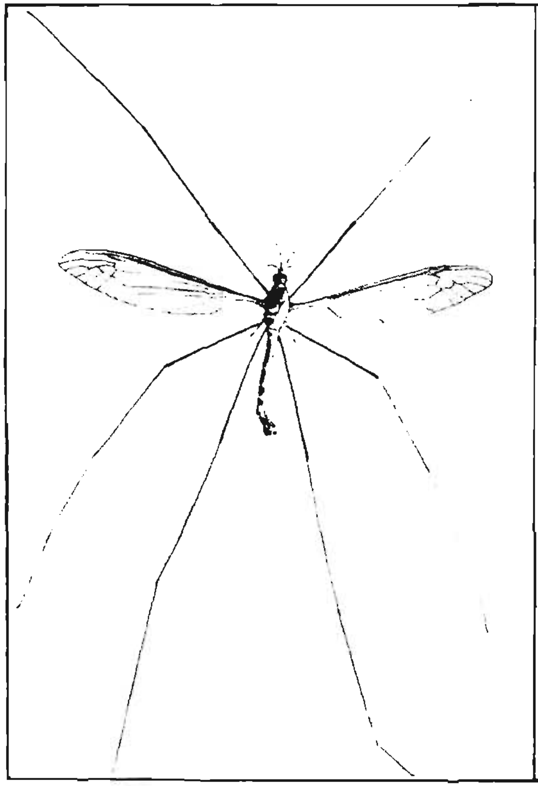


Fig. 1.—Daddy Longlegs or Crane Fly (male).

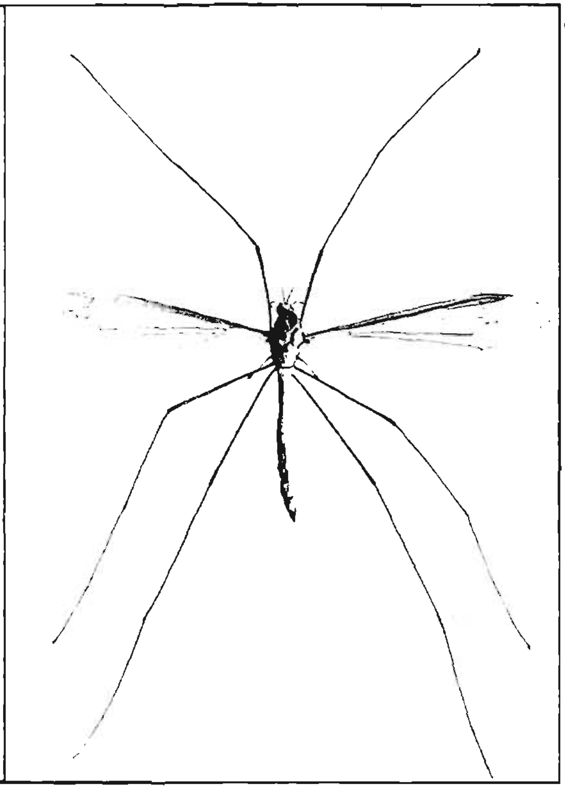


Fig. 2. Daddy Longlegs or Crane Fly (female).

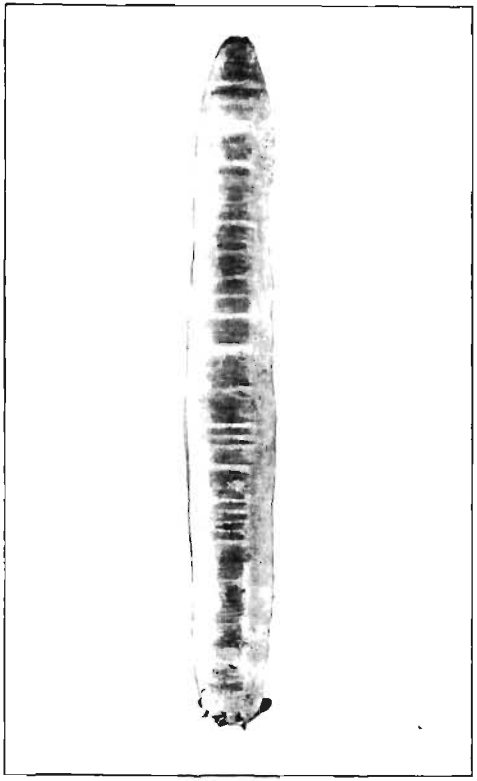


FIG. 3. Larva or Leather-Jacket.

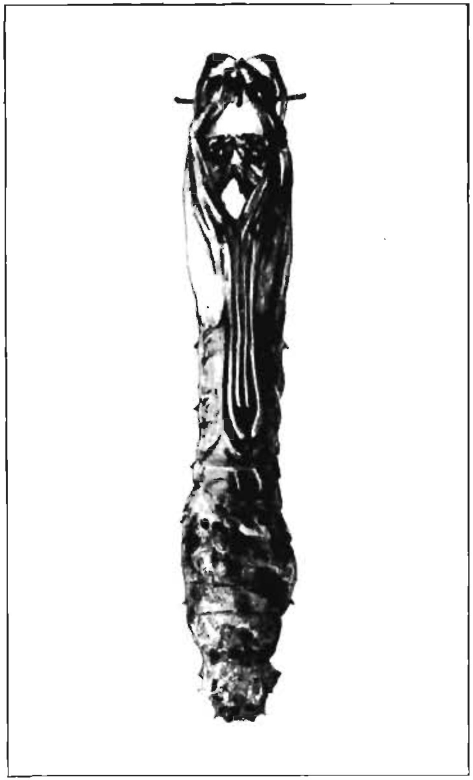


FIG. 4. Empty Pupa Case.

kept alive for fifteen months. The full grown grubs are about $1\frac{1}{2}$ in. long, usually of a brownish-grey, earthy colour of a lighter or darker shade, cylindrical in shape and somewhat resembling some of the "surface caterpillars" (*see* Leaflet No. 33 included in this volume), but the absence of any indications of legs will serve at once to distinguish them. The head, which can be retracted into the body and completely hidden (and usually is so retracted when the grub is at rest), is black. The hind end of the body is cut off squarely and furnished with several fleshy tubercles or projections which protect the two circular "spiracles" or breathing pores. The skin is very tough, attention being called to this fact by the very commonly applied name of "leather jackets." These grubs are present in the soil—usually only an inch or two below the surface—thoughout the autumn, winter and spring. They feed voraciously during mild weather, and will at times migrate in large numbers from one field to another. In the late spring or early summer they cease feeding and turn into pupæ or "chrysalids." Just before the emergence of the flies, the pupæ wriggle themselves half out of the ground, and the empty pupa-cases are left in that position after the flies have escaped.

The life-histories of the other species are probably very similar, but *Tipula oleracea* and *Pachyrhina maculosa* are rather earlier insects than *T. paludosa* and are on the wing from May to August. There is no evidence in support of the contention that any of the species have more than one brood during the year.

Not only the grubs, but also the perfect insects of the two common species of Crane Fly (*Tipula oleracea* and *T. paludosa*) are so much alike that only an expert can distinguish them with certainty.

Natural Control.—Leather jackets are usually most numerous and destructive after an autumn in which the weather has been damp—apparently because the newly hatched grubs are unable to withstand drought. Apart from the effects of weather, leather jackets are also susceptible to the attacks of insect parasites, and of birds—notably pheasants, lapwings, gulls, rooks, and starlings. The latter do inestimable service when the pests are brought to the surface in the course of cultivation, but as a controlling factor, they are of less importance than weather conditions, which appear to decide whether or not a leather jacket epidemic will occur.

Artificial Methods of Control.—A. *Under farm conditions.*—1. Leather jackets are most troublesome to crops following grass or clover leys, but their attacks may be largely avoided if the land is broken up in July or early August, care being

taken to leave the herbage well covered. Both grass and leys intended to be broken should be kept as closely grazed as possible. After the land is broken, it is most important to obtain thorough consolidation and a good tilth; these alone will enable crops to withstand attacks which would otherwise cause serious damage.

2. When a corn crop is being attacked, the field should be given a double harrowing followed by rolling with a heavy Cambridge roller, so as to break down the burrows made by the grubs and consolidate the ground round the roots of the plants. If the land is in poor heart a top dressing of nitrate of soda at the rate of 1-2 cwt. per acre may be given before harrowing.

3. When drilled crops such as turnips, mangolds, or potatoes are attacked, the best plan is to hoe diligently by horse and hand. In this way many of the grubs are destroyed or exposed to the attacks of birds.

4. As a soil insecticide in the case of "leather jacket" attacks, naphthalene has given good results though it is somewhat irregular in action. Naphthalene is a by-product in gas making and may sometimes be obtained very cheaply at a local gas works. In a semi-refined form—the condition in which it is to be preferred—it is usually on sale at large gas works and insecticide makers at prices varying from 7s. 6d. to 17s. per cwt. in accordance with the degree of refinement and state of the market at the time. It should be applied broadcast at the rate of about 2 cwt. per acre (on golf courses it has been used at as high a rate as 5½ cwt. per acre) to affected patches in fields in autumn or spring during showery weather, the effect being largely dependent on a fall of rain soon after the application.

5. It has recently been found that the grubs may be satisfactorily dealt with by broadcasting a bait consisting of moist bran and paris green, but in view of the Protection of Animals Act, 1911, it appears that the poisoned bran may only be used where "all reasonable precautions" are taken "to prevent access thereto of dogs, cats, fowls, or other domestic animals." For this and other reasons the circumstances under which the treatment is advisable are rather limited, and in consequence instructions for preparing the bait are not given in this leaflet.

6. A machine has been devised in Holland for cutting smooth-sided narrow trenches in pasture land; the leather jackets fall into these furrows and are unable to climb out and so perish. The machine consists of a heavy cart under which is fixed a cast-iron wheel which is forced into the ground and cuts the furrow. The furrows must be cut not more than two yards apart. It is reported, however, that this method of control has now been superseded in Holland by the poisoned bait mentioned previously.

B. *Under garden conditions.*—1. These pests should be numerous only in gardens which have been recently converted from grass or waste land, or where the grass and weeds have been abundant the previous summer. In the first case, the breaking of the land in summer is advisable; leather jackets will be avoided, wireworms greatly reduced in number, and the land can be thoroughly cleaned before the first crop is sown. In the case of a weedy garden the remedy is obvious.

2. When an attack is taking place continued hoeing is the best remedy.

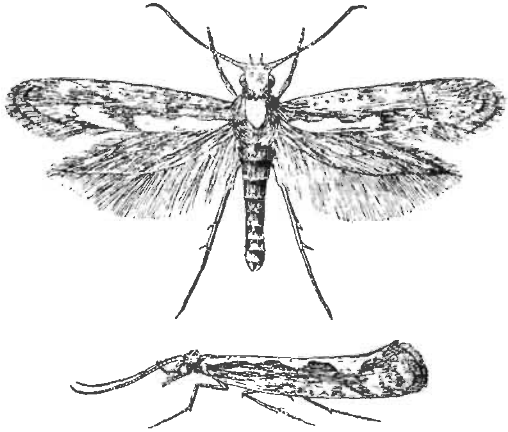
3. It is well to remember that from early summer onwards the grubs pupate and a second crop may often be undamaged *after the first has been destroyed.*

4. Where the grubs are numerous an application of semi-refined naphthalene (*see* p. 40) at the rate of 2-2½ oz. per sq. yard is worthy of a trial. The naphthalene should be worked into the soil, after which a thorough watering is advisable. The chemical seldom does any harm to growing plants but should not be used on seed beds which are just about to be sown as it may retard germination.

5. Sods of turf buried in the ground will attract the grubs. These subsequently can be dug up and the grubs destroyed or given to fowls.

DIAMOND-BACK MOTH

(*Plutella maculipennis*, Curtis).



In nine years out of ten, and even more frequently, this insect is not responsible for any damage of importance and there would be little justification for a leaflet upon it, were it not that every now and again there is a serious epidemic,

in the course of which agriculture suffers to the extent of hundreds of thousands of pounds. When this occurs, there is an immediate demand for full investigation of the trouble, but the very infrequency of the epidemics renders the task of the investigator most difficult, if not impossible, since he has no sooner set to work than the numbers of the moth have returned to the normal and he may have to wait for ten years or more before a chance of dealing with an epidemic recurs. The difficulty is still further increased by the fact that the epidemics occur with great suddenness. In a fortnight, and almost without warning, the crops attacked have been completely ruined, while perhaps a month later, and notably when there have been heavy rainstorms, the insects have disappeared and the outbreak has already become a matter of past history. As a result, the amount of practical information available in regard to the pest is relatively small and measures of control must be treated as suggestive rather than as proved.

Distribution.—The Diamond-back Moth occurs throughout Britain, and indeed practically throughout the world, both in cold and in hot climates. In England it is more abundant on the coast than inland, and more so on the east than on the west coast. In the years of epidemics, the coastal counties of the east of England and of Scotland invariably suffer greater damage than elsewhere.

Plants Attacked and Nature of Damage.—The caterpillars of the Diamond-back Moth feed upon practically every kind of plant of the cabbage tribe, both wild and cultivated. From the agricultural point of view the most important crops attacked are swedes, turnips, the various kales grown for fodder, and sometimes also rape and mustard. Among vegetables cauliflowers are affected and also cabbages. Of the two chief crops, swedes suffer more than turnips. No matter what the crop, damage is similar in every case, the caterpillars eating the foliage, usually the underside only, and leaving the brown shrivelled upper skin or cuticle of the leaf and the main veins. Plants so damaged naturally die unless they are favoured with such growing conditions that they are able to make foliage as fast as the caterpillar can eat it.

Description and Life-History.—The adult moth is quite small, about ¼ in. in length when sitting with folded wings. The prevailing colours are brown and grey, while on each wing are three whitish triangular spots near to the hind margin, which meet when the wings are folded and then appear like diamond-shaped marks along the back of the

moth, the character by which the species may easily be recognised. Adult moths appear in May and June, hatching out from chrysalids, in which stage the insect has passed the winter. The females then lay eggs on any plant of the cabbage tribe, including such weeds as charlock and hedge mustard. The eggs hatch into caterpillars, which are green in colour and live in a slight web which they spin across the undersurface of the leaf upon which they feed in the manner already described. When full fed, in three weeks more or less according to the weather, they spin small white silken cocoons within which they turn into chrysalids. After a fortnight or so, in the course of the summer the adult moths emerge from the chrysalids and the whole cycle begins again. It is not certain how many generations there may be during the summer, but moths may be found in every month from the middle of spring until October. It would, therefore, seem that the species breeds continuously, one brood following another throughout the summer, the exact number depending on weather conditions and the amount of food available. In any case, the chrysalids of the caterpillars from the last brood in the autumn remain in their cocoons attached to the dead stems of charlock, hedge mustard, &c., and give rise to moths in the following spring. It may be mentioned that it is very probable, if not certain, that the home population of Diamond-back Moth is from time to time increased by immigration from the Continent, but there is no evidence to suggest that the epidemics are due to these foreigners from abroad.

Nature's Check on the Species.—In the case of an insect such as the Diamond-back Moth, which breeds continuously, it is clear that an epidemic would occur every year if the numbers of the insect were not controlled by some natural agency. The most effective controlling force in connection with this species is wet weather and notably heavy rains. Even when a serious outbreak is in full progress, a week of stormy wet weather is sufficient to reduce the pest to negligible proportions. The next most important factor in natural control is the attack of certain species of ichneumon fly, to which the caterpillars are very subject. If an epidemic is not checked by weather, it is often found that towards the end of the outbreak it is quite difficult to obtain healthy caterpillars, almost every one being attacked by the larvæ of one of the beneficial ichneumon flies which feed within the bodies of the caterpillars, ultimately causing their death. Lastly, during an outbreak, birds, especially lapwings and starlings, have proved most beneficial by feeding on the caterpillars, and are said to have saved fields of turnips otherwise doomed.

Methods of Control.—(1) The first essential in dealing with the Diamond-back is to discover the caterpillars early, while in fact the crop is still green and healthy, for nothing can be done with dead plants. This implies careful inspection whenever conditions favouring an outbreak occur, that is to say, when June and early July have been warm and bright. Turnip and swede fields can then be examined, turning up a leaf here and there and looking not only for minute green caterpillars, but also for small moths with the diamond-shaped mark, which fly readily when disturbed. If moths only are found, a watch should be kept on the fields and subsequent inspection should show whether caterpillars are present in numbers. As soon as caterpillars can be found in plenty and the first signs of damage can be observed, one or other of the following treatments can be tried.

(2) An old remedy which appears to have given good results is to brush and dust the plants by some such home-made device as a scuffler with twiggy branches attached in such a way that they sweep along the rows. The twigs tend to brush the caterpillars from the undersides of the leaves and also to dust the latter and so render them less readily eaten by the pest. Others have used bags moistened with paraffin, which are dragged over the plants and have a somewhat similar effect to the twigs. In the use of these home-made implements, there is, of course, much variety in construction in accordance with the materials available on the farm, but the great thing is to brush well the undersides of the leaves, continuing the treatment so long as caterpillars can be found in abundance on the foliage.

(3) Another old remedy which, if applied sufficiently early, appears to have given good results is to dust the plants very thoroughly with ground lime or lime and soot. Still better results should be obtained by substituting a powder insecticide such as nicotine powder for the lime or lime and soot. In any case the success of the treatment depends on getting the dust where it is wanted, underneath the leaves, and this is far more likely to be done by the use of a proper dry sprayer than by sowing with the hand. Any devices which can be attached to the sprayer to brush the leaves upwards while the dust is being forced into the plants will be an advantage. In the United States dry sprayers (horse drawn) are fitted with some form of shield or cover to go over the crop at the points to which the nozzles are directed and so prevent the powder from being blown away and wasted. This kind of device would add greatly to the efficiency of a sprayer used for Diamond-back Moth.

(4) Wet spraying does not seem to have given very good results because of the difficulty in spraying the undersides of the turnip or swede leaves. If this difficulty can be overcome, almost any insecticide, lead arsenate, derris, &c.,

should be effective. Dry spraying with a light powder insecticide is, however, a much more hopeful measure.

(5) Advice as to the destruction of the weed food plants of the Diamond-back Moth—charlock, &c.—is usually given; such advice is undoubtedly sound, but it is questionable whether a farmer who will not destroy his weeds as a matter of "good husbandry" will do so on account of this pest. It can only be suggested that the Diamond-back Moth forms yet another reason for the destruction of weeds.

(6) Some similar advice applies to the protection of useful birds, notably the lapwing. There are already many reasons for protecting this species and for encouraging it to breed on or close to the farm: the chance of a Diamond-back Moth epidemic constitutes one more reason.

FLEA BEETLES.

Introduction.—All who have grown turnips, cabbages and similar crops will be only too familiar with the pests which pass under the names Flea Beetles, Turnip Flea or Turnip Fly: in the aggregate the damage which is caused by these insects must be enormous. Moreover, turnips and plants of the cabbage tribe are not the only crops attacked, for there are many species of Flea Beetles with different habits, and at times mangolds, barley, hops, and even potatoes, may suffer greatly. This leaflet, however, deals mainly with the species which attack turnips, other plants of the cabbage tribe, and mangolds. Flea Beetles occur throughout the United Kingdom and in fact are known as pests in practically every country in the world, though the species found abroad are not of course in all cases the same as those known in Britain.

Nature of Damage.—The chief damage is done when the adult beetles attack the first two leaves of the crop as they appear through the soil, eating them away and often destroying the seedlings completely. Damage is also done when the plants are in the "rough leaf," but it is less serious, and as a rule the crop is then able to grow away from the attack, though in an unfavourable season the check may cause appreciable loss. Unfortunately the beetles are most active and appear most numerous in dry, hot weather, just when the crop is standing still or growing slowly, and under such conditions it is not uncommon to find two or even three sowings cleared off entirely. Turnips and swedes perhaps suffer most, but rape and mustard are almost as liable to attack, while all vegetables of the cabbage tribe may be destroyed while in the seed bed. Mangolds are not so often damaged, possibly because they are less affected by drought,

or are grown on soil which naturally retains moisture better, but at times (as, for instance, in 1918) they may suffer equally with swedes and turnips.

Description and Life-History.—The two most common Flea Beetles (*Phyllotreta undulata*, Fig. 1, and *P. nemorum*) are minute (one-tenth of an inch long) black beetles with a yellow stripe down each wing-case (elytron) but in company with them are often found Flea Beetles which are quite black (*Phyllotreta consobrina*, &c.), metallic blue (*P. cruciferæ*), or brassy black (*Plectroscelis concinna*, Fig. 2). The last named is the one which is chiefly responsible for the damage to mangolds (and hops).

On account of their small size Flea Beetles are not very conspicuous, though their presence is always obvious enough from the characteristic damage to the leaves. On the slightest disturbance they jump like fleas and soon become hidden among small lumps and clods of earth, where they are easily overlooked.

It is impossible to give a full account of the habits of all the common species of Flea Beetle; in most cases there is still room for investigation, but it may first be mentioned that practically all spend the winter as adult beetles hidden under bark on trees, in hedge bottoms, heaps of refuse, stacks, &c. Thousands, for instance, may be found in the bottom of a hay-stack which has been put up near a turnip field. In the spring the beetles come out and at first feed on any plants of the cabbage family which may be available—horse-radish, rape and turnip when kept for seed, charlock, and many other weeds. On warm days the beetles fly freely and probably for considerable distances, for as soon as the turnips, swedes or cabbages appear above the ground the beetles collect on them, feeding on the seed leaves.

During June, July and August, eggs are laid and after this there appear to be differences in the habits of the various species. According to a recent investigator*, in the case of the Larger Striped Flea Beetle (*P. nemorum*) and probably of the Lesser Striped Flea Beetle (*P. undulata*) also, the eggs are laid on the soil near the plants, though many other writers state that the eggs are laid on the leaves. In the case of the first-named beetle (*P. nemorum*) the larvæ on hatching crawl up and mine into the leaves, while in the case of the latter the larvæ burrow down and feed on the roots, though they may perhaps also attack the upper parts of the plant. In either case the larvæ when full-fed crawl into the soil, pupate, and after some ten days or more turn into the adult beetles which make their way out of the soil and start feeding on the turnips, &c. The length of time spent in the egg,

* Taylor, *Entomologist*, Vol. 51, p. 83.

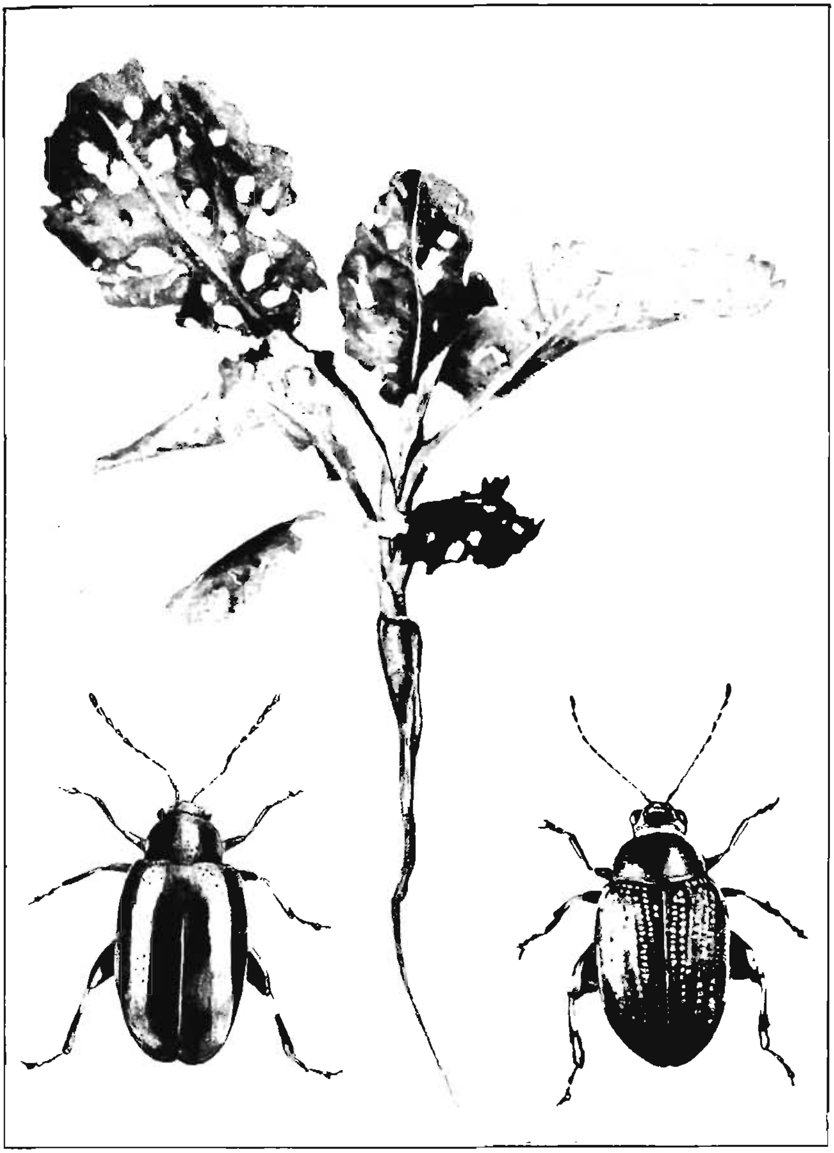


FIG. 1. FIG. 3. FIG. 2.

FIG. 1.—Lesser Striped Flea Beetle (*Phyllotreta undulata*, Kutz).
FIG. 2.—Mangold Flea Beetle (*Plectroscelis concinna*, Marsh).
FIG. 3.—Attacked Turnip Plant.

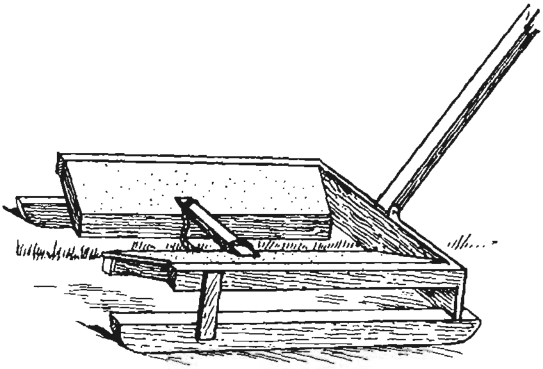


FIG. 4.—Flea Beetle Trap.

larval and pupal stages appears to be from six to ten weeks. The adult beetles live from the latter half of summer through the winter and on until July or even August of the following year, when their place is taken by beetles of the next generation.

Methods of Control.—1. In the first place everything possible should be done to reduce the numbers of the pest by clearing out and burning the rubbish from hedge bottoms, dykes, &c. All farm refuse should be burnt when it cannot be worked into a properly made compost heap.

2. An increase in charlock will be accompanied by an increase in the numbers of Flea Beetles, and this alone would be sufficient reason for dealing with it either by spraying or hand pulling.

3. Obviously the object at which to aim is a rapid growth on the part of the young plant. This may largely depend on the weather, but nevertheless a fine tilth free from clods combined with suitable manuring will at all events go far to help the plant through the dangerous period.

4. It is often claimed that dressing the seed with paraffin, or preferably turpentine, is of great value in avoiding an attack. A dessertspoonful of turpentine is said to be sufficient for 7 lb. of seed.

5. When an attack is in progress there are various measures which may be employed. The oldest is to dust the plants with fine soil by hoeing or by driving sheep through the field. Basic slag dusted along the rows when the dew is still on the plants is also said to have proved effective.

6. Various devices have been used for catching the beetles and undoubtedly they can be useful. They all work on the principle of disturbing the beetles, causing them to jump, when they are caught on tarred boards or sacks. There is no standard pattern for these machines as they are made up from any material which may be available on the farm. A very simple form, for instance, consists of two old bicycle or perambulator wheels joined together by an axle from which hangs a fringe of material—old bags, for instance—about two to three feet wide and the length of the axle. A pair of handles is also attached to the axle. The bags are then well tarred or covered with grease-banding material to within about six inches of the ground, and the whole apparatus is *pushed* (not pulled) by a boy up and down the field. The tarred side hangs downward and sweeps over the plants, causing the beetles to jump up and stick to the tar. Much depends on keeping the tar fresh and doing the work well.

More efficient machines than this can easily be made on the principle of that illustrated (Fig. 4) for use on garden crops. This trap was invented by Professor Lefroy and was tested at

the Royal Horticultural Society's Gardens at Wisley, where it was found most effective.

The apparatus consists of a framework, on runners (or small wheels), made to carry two pieces of thin board 20 inches long by 5 inches wide, placed side by side but with the outer edge higher than the inner edge, *i.e.*, sloping outwards and upwards, and with a clear space of 4 inches between the inner edges. These two sloping boards must be connected *just before the middle* by a cross-bar, and behind by a back board. A loop of cord is tied to the cross-bar so that it barely touches the ground, and when in use the surface of the sloping boards, the cross-bar and the back board, must be coated with some sticky substance such as tar or grease-banding material.

The trap is pushed along the rows of turnips, mangolds, &c., in such a position that the loop of cord brushes the young plants. The beetles are thus disturbed and, leaping up, alight and are caught upon the sticky boards. It is necessary to renew the sticky surface occasionally during the process of the work.

7. Spraying is also well worth testing, as in America and Canada both lead arsenate and paraffin emulsion are said to have given quite satisfactory results, while many writers in this country record good results with paraffin alone. Potato sprayers are now available on many farms and allotments, and there is no excuse for allowing crops to be eaten off without making an effort to save them. The following are formulæ for making paraffin emulsion and lead arsenate washes. It is suggested that the former should first be tried.

(*a*) Paraffin Emulsion.

Paraffin	2 pints.
Soft Soap	1 lb.
Water	10 gallons.

Dissolve the soft soap in about a gallon of boiling water, remove the soap solution from near the fire and while still hot add the paraffin. Churn the mixture very thoroughly by syringing it back into itself, add soft water to make 10 gallons, and before using make sure that there is no free paraffin floating on the surface.

(*b*) Lead Arsenate Wash.

Lead Arsenate Paste	1 lb.
Water	20-25 gallons.

Mix the lead arsenate paste with a little of the water to the consistency of thin cream and then add the rest of the water.

8. Dusting with insecticide powders can also be effective. Powdered naphthalene was recently tested on a seed bed of cabbages which was being badly attacked, 1 oz. of powdered naphthalene being allowed to each row—about 30 ft. long by 2½-3 in. wide. No further damage was done. Pyrethrum

powder should also prove useful, and the old remedies, soot and lime, scattered on the plants when damp can be employed when no other remedies are available.

THE FRIT FLY

(*Oscinis frit*).

The Frit Fly is responsible for very great damage to cereal crops throughout the whole of Northern and Central Europe and the British Isles, while the larvæ of this or of other species of *Oscinis* are injurious to cereals in Canada and the United States of America. In England the severity of the attack varies from year to year. In bad years serious damage is done almost throughout the whole country except perhaps in the Fens, in other years damage may occur locally anywhere.

It was previously thought that the north of England suffered less than the south, but recently serious losses have occurred in the four northern counties, and the absence of older records is perhaps due more to a failure to recognise the symptoms of damage than to a comparative absence of the pest. Even now, when Frit Fly has become well known in agricultural circles, damage caused by this pest is not infrequently ascribed to wireworm and eelworm.

Plants attacked and Nature of Damage.—In England by far the greatest damage is done to spring-sown oats, but, among other cereals, winter oats, winter and spring-sown wheat, barley, and rye have been attacked, and possibly suffer greater injury than is usually recognised.

Oats.—Damage to spring-sown oats becomes apparent in late spring or early summer, when it is found that the main shoot and possibly the first-formed tillers cease to grow, the young central leaf of the shoot dying, though the outer sheathing leaves may remain green. Each shoot which is so attacked becomes incapable of producing an " ear," and the whole plant, if at all weakly, is likely to die. Established plants when badly attacked continue to form new tillers which in their turn are also infested, the process continuing until the plant more resembles a tuft of grass than a normal oat. These late-formed tillers produce either a weak or useless ear or none at all.

A fresh attack takes place in July, in this case the *ears* being injured by the larvæ which may be found living on the young soft corn, either completely destroying it or so damaging it as to render it worthless. It is probable that this attack is often overlooked, since the effect in the field is not very obvious, the very light weight of the crop when threshed

being the first indication of damage. Should, however, the threshing take place at harvest, the cause of the light weight of the crop may become very apparent from the enormous number of flies that will issue from the stored grain. From the above statement it will be gathered that a crop may be ruined as a result of either the first or second attacks, and the necessity of avoiding the first attack in order to escape the second would appear to be obvious, though further information is required as to the extent to which the second attack is dependent upon the first.

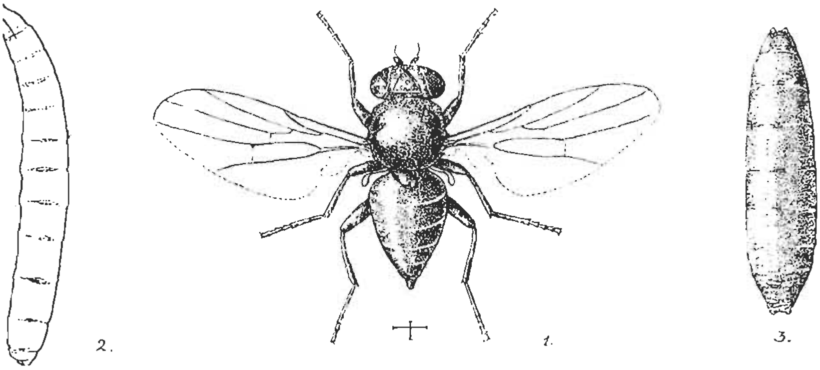
Frit Fly and eelworm attacks often occur together, but apart from this a Frit attack is often confused with an eelworm attack and recorded under that name. Perhaps the best superficial characters by which to judge an eelworm attack are the more swollen base of the plant and the absence of the white Frit grub; growers, however, are advised not to rely upon their own diagnosis, but to consult an expert.

Wheat and Barley.—The attack on young plants is very similar to that on oats, and the effects are practically the same, but the second attack on the ear appears to be much rarer in England than in Scandinavian countries.

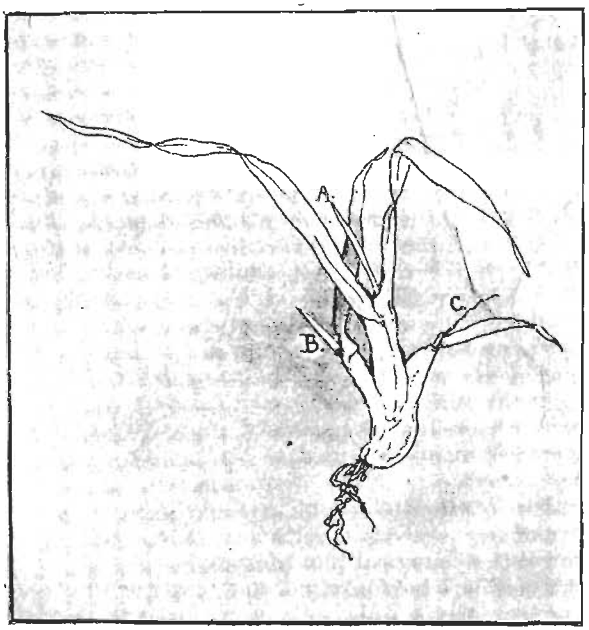
Grasses.—Frit-like larvæ (whether of the species attacking cereals or of some allied species is not always clear) have been found in the following grasses:—*Poa annua* (annual meadow grass), *Poa pratensis* (smooth meadow grass), *Agropyron repens* (couch grass), *Lolium perenne* (rye grass), *Lolium italicum* (Italian rye grass), *Phleum pratense* (timothy grass), *Alopecurus pratensis* (meadow fox-tail grass), *Milium effusum* (wood millet grass), *Festuca pratensis* (meadow fescue-grass), *Avena flavescens* (yellow oat-grass), and *Arrhenatherum avenaceum* (common oat-grass) and its variety *bulbosum* (onion couch or knot-grass). It is therefore probable that on most farms there must always be a large natural reservoir of flies. On the Continent larvæ have also been found on *Triticum cristatum*.

Description and Life History.—Eggs are laid by the female in the late autumn on the leaves or stems of grasses, and occasionally perhaps on winter wheat and winter oats (on the Continent very commonly on rye). These eggs quickly hatch, and the young larvæ make their way to the centre of the young shoot, which they ultimately destroy; here (usually close down to the base of the shoot) the minute white grub, about $\frac{1}{8}$ in. in length and without legs, may be found throughout the winter. In the spring the grub changes to a pupa inside a reddish-brown puparium or pupa-case, either where it has been feeding or at varying heights under the outer leaf sheaths.

From this pupa emerges the adult fly, which is a minute shining black insect with a characteristic short



1. Adult Fly. 2. Larva. 3. Puparium.



Oat plant attacked by Frit.
A. Healthy tiller. B. Attacked tiller, early stage.
C. Attacked tiller, late stage.

hopping flight. The date of the appearance (or at least the period of maximum prevalence) of this spring brood of flies is of great importance, for if the spring oats have by this time reached a sufficiently advanced stage of growth, the crop will suffer little damage. The evidence so far available suggests (1) that the date of maximum prevalence is rather constant (in Herts and Oxfordshire, for instance, it seems to lie between May 21st and June 1st), and (2) that oat plants which have developed four leaves (not including the central leaf) by the time the flies emerge will not be greatly injured.

The female flies thus appearing in spring lay their eggs on the spring-sown corn (chiefly oats) and pass through the same transformations with the same injury to the plant as in the previous generation, but the time spent in undergoing these transformations is much shorter (six to eight weeks), the flies of this, the second, generation appearing during July, ready to lay their eggs on the ears, or young corn in the ears. The flies of the third generation appear during August and September, the females laying their eggs on grasses and possibly on autumn-sown corn.

The above is a brief history of Frit Flies during the year, but variation in many respects is not only probable but certain; though these variations have by no means been thoroughly studied, it may be stated with confidence that more than three broods are possible during the year, and that the different broods are seldom sharply differentiated, several observers having noted that the fly may be found in all stages at any time between the spring and late autumn. Volunteer corn plants (those growing after harvest from corn shaken out of the ears in the field) are very often attacked, pointing to the advisability of early ploughing of stubbles; and in connection with this it should be noted that the ploughing-in of infested plants after the larvæ have pupated is probably of little use in destroying the insect, for in experiments carried out in Russia by Krassiltchik and Vitkovsky in 1913 it was found that flies were capable of getting through 7 to 9 inches of rammed wet earth upon emergence from pupæ buried at that depth.

Methods of Control.—Oats.—*Early sowing* and a *good tilth* are of the greatest importance. The object to be aimed at is to get the young oat plant forward as rapidly as possible, but it must not be forgotten that early sowing on a bad tilth, or too early sowing with injury from frost, may result in a more backward plant than somewhat later sowing. The relatively small amount of damage to spring oats in the Fens appears to be due to the fact that the soil is easily worked into a perfect tilth and in consequence the seed is sown under very favourable conditions.

Manuring.—The growth of the young plant may be accelerated by the use of suitable stimulating manures, which must be readily available as soon as needed; nitrogenous manures are naturally of most importance for this purpose, and should be harrowed in with the seed. or just before sowing. It must be remembered that, so far as Frit is concerned, the manure is chiefly needed during the early stages of growth and may be harmful if used too freely, as it will tend to cause the oats to " lodge " or become laid; while further it is likely to retard the ripening of the grain and so conduce to additional damage by the pest to the corn. Phosphatic manures should assist in counteracting this later effect.

Once an attack is far advanced little can be done; top dressings of sulphate of ammonia do not appear to have given good results, but nitrate of soda is said to be effective if applied sufficiently early.

Interesting and instructive experiments on the value of suitable manuring on the growth and yield of Frit-infested oats in Russia were published by Vassiliev in 1914; the number of plants completely destroyed by Frit Fly was reduced from 21 per cent. in unmanured plots to 5½ per cent. in those suitably manured; the number of plants failing to produce normal grain was reduced from 48½ per cent. in unmanured plots to 11 per cent. in those manured, while the yield of grain was increased by 37 per cent. in one case and 65 per cent. in another. As a result of his experiments, Vassiliev came to the conclusion that the damage, done by anything up to a 40 per cent. infestation of the young plants by Frit Fly, could be reduced to a negligible quantity by an application at the proper time of suitable manures under conditions favourable to growth.

Subsequent observations in England tend to show that the Russian experimenter was too optimistic, but there is at least no doubt that manuring is of great importance in assisting the crop to avoid injury.

Wheat.—In this country winter corn crops appear only to suffer when sown after a grass ley, notably after rye grass (whether in a clover mixture or not). Apparently the Frit larvæ are ploughed under with the sod and, as the grass decays, work their way up and bore into the growing wheat. The obvious preventive measure is not to sow winter wheat after such leys unless the latter can be ploughed sufficiently early—that is to say before harvest. Experiments carried out by Petherbridge at the Cambridge School of Agriculture have proved this measure to be successful.

Varieties of Oats.—Considerable attention has been given to the discovery of an oat resistant to Frit attack, a line of

investigation encouraged by the fact that, in any variety trial, the different kinds of oat exhibit a marked variation in the extent to which they suffer Frit injury. Unfortunately it is found that the results gained in one locality and one season do not often tally with those obtained in another season or another locality. In many cases it is believed that these inconsistent results are due to experimental errors which are difficult to avoid in a variety trial. However this may be it is not yet possible to recommend any spring oat as being definitely resistant. The best advice which can be given on this subject is that the variety should be grown which proves to be earliest in the district in question. In a district bad for Frit (which is probably the same as saying " on a soil in which it is seldom possible to sow oats early ") it is preferable to grow a rapidly maturing oat even if there is some loss in yield. The other course is to avoid spring oats altogether and to sow instead winter oats which suffer little, if any, damage. The Frit pest has indeed forced this alternative in many districts where losses to spring oats rendered the crop unprofitable.

THE GOUT FLY

(*Chlorops tæniopus*, Meigen).

The Gout Fly is a common insect throughout the British Isles and is responsible in some seasons for great damage to wheat and barley, notably the latter. The pest is equally common and destructive on the Continent and its ravages in Central Europe between 1865 and 1870 were of a most disastrous nature. It does not appear to have been recognised as a pest to cereals outside Europe.

Plants Attacked and Nature of Damage.—In England barley suffers most damage, but wheat and rye may be attacked. The pest can also live upon wild grasses, couch grass being the kind preferred.

Barley.—The nature of the injury varies somewhat in accordance as to whether the plant is early or backward. In the average crop the damage is done during the fortnight or three weeks before the ear appears and is caused by the larva (maggot) of the summer brood of flies, which burrows down the side of the ear to the first joint. As a result, growth in an upward direction is checked, the plant becomes swollen and gouty as in Fig. *d* and the ear never matures. If the crop is forward the check to the plant is less marked and the ear escapes from the sheath showing more or less evidence of attack in its poor development and in the destruction of kernels down one side.

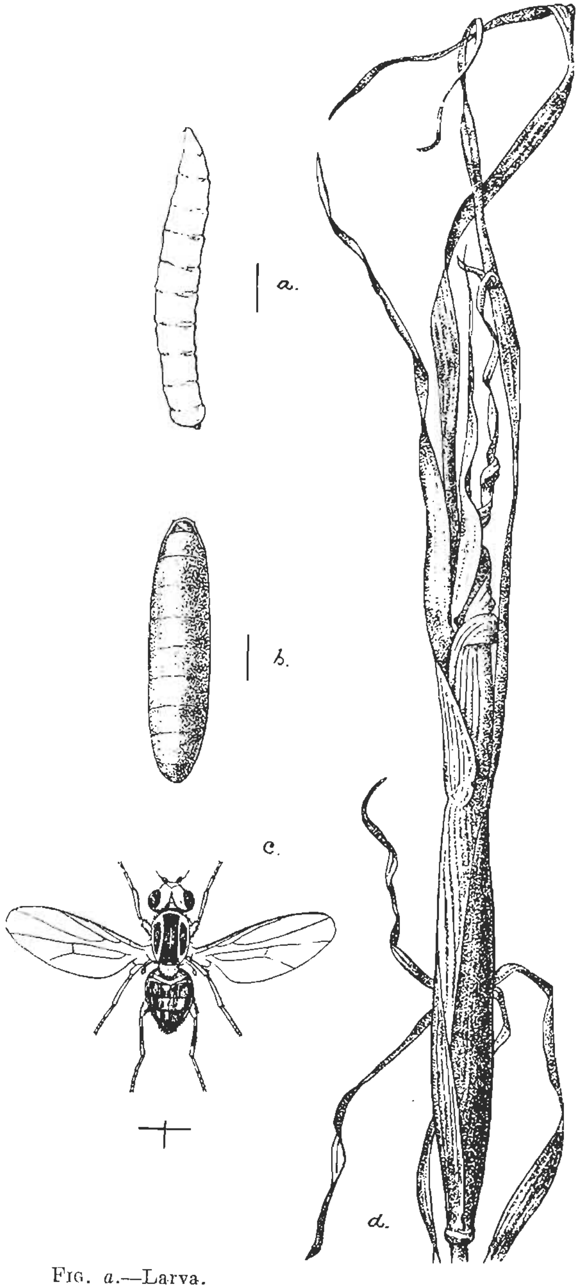


Fig. *a.*—Larva.
Fig. *b.*—Puparium.
Fig. *c.*—Fly.
Fig. *d.*—Stunted and distorted barley.

If on the other hand the crop is backward the attack may occur before the plants have begun to run up and in this case the attacked tillers remain only a few inches high, gouty and swollen in shape, and of course never grow to produce an ear.

Wheat and Rye.—The usual attack on wheat and rye is by the larvæ arising from autumn laid eggs, which feed in the young plant during the winter and produce the same symptoms as in the backward barley—the attacked tillers become swollen and gouty, never growing to more than a few inches high. The plant may die altogether or other tillers may run up in spring and ultimately produce ears, usually of a weakly character. Wheat may also suffer from the summer brood of maggots in the same way as barley but this form of attack appears to be rare.

Description and Life-History.—The flies appear in May and June. They are only about one-sixth of an inch long (Fig. *c*), and one-quarter of an inch in spread of wings. The head is yellow with a black triangular mark on its upper surface; the thorax is yellow with three prominent longitudinal black stripes upon its upper surface. The eyes are large and when the insect is alive are green in colour. Only an expert can distinguish these flies from many harmless species which they closely resemble. Minute eggs, elongate-oval in shape and of a creamy-white colour, are laid by the female flies on the leaves surrounding the central shoot. The maggot or larva hatches out in about ten days and passes inwards to the centre of the shoot. Here it feeds, working down the ear and the stem and forming a groove or furrow (without penetrating the inner canal) until it reaches the first joint (node). The Gout-Fly larva (Fig. *a*) is a yellowish-white maggot, legless, and about one-fifth to one-quarter of an inch in length when full-grown. After about a month's feeding it changes to a brownish, somewhat flattened puparium (Fig. *b*), which lies at the first node or in the folds of the leaves encircling the spoilt ear. A new brood of flies issues from these puparia in about 36 days (from August onwards) and may sometimes be found in myriads about recently stacked barley which has been attacked when in the field. These flies lay their eggs upon wild grasses (couch), volunteer corn in stubble fields, or on autumn-sown corn, and the young maggots pass the winter in the centre of the plant close down to the root. Infested plants become very bulbous or gouty in winter or early spring. The maggots change to puparia in spring and flies hatch out in May or June ready to continue the cycle of operations. In addition to the winter and summer broods mentioned above it is possible that in favourable seasons there may be a partial third brood in the autumn.

Methods of Control.—1. It has been proved by observations made by various writers that Gout-Fly attacks are worst on late-sown crops or on those which are not doing well—as, for instance, when grown on poor, badly drained and badly cultivated land. It therefore follows that the early sowing of barley combined with good cultivation and attention to drainage are of primary importance in districts where Gout Fly is found to give trouble.

2. In such districts, chiefly in the south-west, winter wheat should not be sown too early in the autumn so that by the time the young plants are up the late brood of flies will have ceased egg-laying. The application of a top-dressing of some stimulating artificial manure will help a wheat crop to escape serious injury.

3. Experiments carried out at Rothamsted* show that manuring has a marked influence on the damage done to spring barley by Gout Fly—manures favouring the growth of the ear causing a definite reduction in injury. The general deductions were that farm-yard manure and superphosphate were most beneficial, while an excess of nitrogenous manure such as ammonium nitrate was actually harmful by retarding the development of the ear.

4. Attacks must be expected on land allowed to become foul with couch and other grasses.

Natural Enemies.—Two species of parasitic "Ichneumon Flies" play a conspicuous part in acting as checks on the unlimited increase of the Gout Fly. One of them—known as *Cœlinius niger*—has a shining black thorax, reddish-brown abdomen, and beautifully iridescent wings. The other—*Pteromalus micans*—is of a brilliant metallic green colour with blue and violet reflections, and iridescent wings without a network of veins. The importance of these parasites has led to the omission of the advice that "cavings" (trash) from threshed barley stacks should be burned if the crop has suffered from "Gout." It appears that although a large number of apparently sound "puparia" may be found in such "cavings," nevertheless most of them contain parasites and not Gout Flies, which have hatched out earlier and have flown away. It is therefore probable that the burning of cavings would only do harm as the beneficial parasites and not the Gout Flies would be destroyed.

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* Frew. *Annals of Applied Biology*, XI, pp. 175-219.

MANGOLD FLY
(*Pegomyia betae*, Curtis).

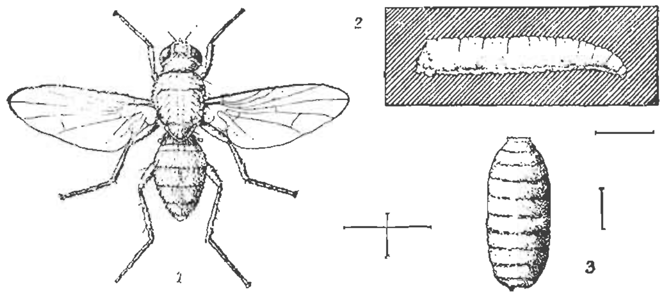

FIG. 1.—Adult Fly. 2.—Larva. 3.—Puparium.

The Mangold Fly as an enemy of sugar-beet, mangolds and spinach is well known throughout Europe and North America. In the British Isles it chiefly attacks mangolds, but various other plants, such as henbane, belladonna and goosefoot serve as food-plants for the larvæ. The extension in the growing of sugar beet renders it likely that this crop will be increasingly subject to the attacks of the pest.

The damage caused by the fly is most serious when the plants are attacked at an early stage, especially when weather conditions are against rapid growth—crops of sugar-beet suffering greatly under these circumstances—but even later attacks reduce the weight of the crop through lowering the vitality of the plants. The fly is much more numerous in some seasons than in others; there are years when its numbers may be so reduced owing to unknown factors that it becomes comparatively harmless.

Nature of Injury.—After mangold plants have been singled and begin to show growth they sometimes suddenly droop and present a withered appearance. Upon examination pale blotches, like blisters, will be found upon the leaves; these are caused by the maggots of the fly feeding upon the tissues between the upper and lower skins of the leaf. These discoloured patches become brown and withered, and the growth of the plants is seriously retarded; when the attack is severe and weather conditions are unfavourable, small plants may be killed outright.

Description and Life-History.—The fly appears in spring. and the female lays her eggs on the undersurface of the leaf. sometimes singly but more often in groups. The number of eggs in a group varies from two or three to as many as twenty, or occasionally even more; not infrequently more than one group is found on a single leaf. The eggs are elongate oval, about 1/30th of an inch in length, and pure white. From these eggs the creamy-white legless larvæ hatch in about four to five days, and immediately bore their

way through the outer skin into the central leaf tissue in which they mine, thereby producing the blisters on the leaves. When full-fed the larvæ are about one-third of an inch long, pointed at the head end, and squarely blunt at the tail end. After feeding for about ten to fifteen days the larvæ pupate, turning into brown puparia or "chrysalids." Usually they burrow about two inches into the earth for pupation, but some larvæ in the earlier parts of the year pupate in the leaves, near their margins. From the puparia the adult flies emerge in about fourteen to twenty days, the whole life-history from egg to perfect insect thus occupying from thirty to forty days.

There are at least three broods during the year, but these greatly overlap as the season progresses. All the larvæ of the last brood pupate in the soil, and the winter is spent in the puparium stage.

Methods of Control.—(1) When farmyard manure is used on land intended for mangolds or sugar-beet, it should be applied and ploughed in as early as possible, as the presence of fresh manure on the land in spring is said to attract the flies.

(2) Crops should be assisted to grow away from a possible attack by ensuring a good tilth and liberal manuring.

(3) Though perhaps not commercially worth while for large areas, in exceptional cases (such as might arise in the event of a valuable variety of mangold grown for seed being attacked) spraying the plants in order to kill the young larvæ might be effective if carried out sufficiently early. An emulsion according to the following formula might be tried:—

Soft soap	1 lb.
Paraffin	1 pint.
Nicotine (95 %)	$\frac{3}{4}$ oz.
Water	10 gall.

Dissolve the soft soap in 1-2 gallons of boiling water. Emulsify the paraffin in a hot soft soap solution by taking up the paraffin in a garden syringe, a syringe-full at a time, and squirting it violently into the soap solution. Dilute to 10 gallons by the addition of 8-9 gallons of water as required. Add the nicotine and stir well before using.

Natural Enemies.—Several parasitic insects have been reared in this country from the maggots of the mangold fly, and these probably considerably reduce the numbers of the intermediate broods of the pest. In the spring and autumn the parasites are not so plentiful as in summer. Birds, especially starlings, have been found to consume large numbers of the maggots on the Continent. They probably also destroy many of the hibernating puparia in the soil.

In certain cases rolling is reported to have given good results. When the nature of the soil and state of the plant allows it, this treatment should be tested experimentally.

MILLEPEDES AND CENTIPEDES.

Millepedes and centipedes belong to the group of the animal kingdom known as *Myriapoda.* They are closely allied to insects (*Insecta*) but differ from them in many characters, among which the most obvious is the possession of one or two pairs of legs to almost every segment. In general appearance the more common forms are quite distinct from all other land animals occurring in this country. Owing, however, to the fact that they are sometimes referred to as "wireworms," confusion often arises between them and the true wireworms, which are the larvæ of various click beetles (*see* p. 106, *Wireworms*). The possession of more than three pairs of legs will at once distinguish the millepede or centipede from the click beetle larva, to which the term wireworm should be confined.

Millepedes and centipedes are somewhat alike in general form, and since millepedes are distinctly injurious, while centipedes are on the whole beneficial, it is necessary to distinguish clearly between them. The following points will serve for this purpose. Millepedes have *two* pairs of legs to each segment of the body, which, with the exception of the genus *Polydesmus*, is rounded or cylindrical in form. Centipedes have only *one* pair of legs to each segment of the body, which is somewhat flattened. In addition millepedes are rather sluggish in habit and when disturbed coil themselves up like a watch spring, while centipedes are active and usually escape by running as soon as they are discovered.

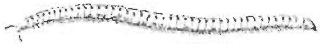

FIG. 1.

FIG. 2.

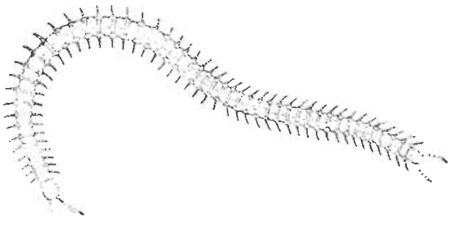

FIG. 3.

Figs. 1 and 2, Millepedes (1, *Julus pulchellus* × 3; 2, *Polydesmus complanatus* × $1\frac{2}{3}$); Fig. 3, Centipede (*Geophilus subterraneus*, magnified).

Centipedes.—As centipedes are not injurious to plants they may be dealt with briefly. The common genera in Britain are *Lithobius* and *Geophilus*. The former is rather large and stout, of a uniform brown colour, and is often to be found under stones and logs of wood. *Geophilus* differs from *Lithobius* in being long and slender; it is sometimes found under stones, but is more common in leaf mould and in the surface layers of the soil. Centipedes are carnivorous and feed mainly on small slugs, snails and insects.

Mention should, perhaps, be made of the fact that some centipedes notably *Geophilus electricus*, Mein., are at times phosphorescent and yield quite a bright light. Little is known of the origin of this phosphorescence, but it appears to be derived from some material on the surface of the animal, which may leave a glowing track as it passes along.

Millepedes.—Millepedes of several genera are found in Britain, but for practical purposes it will suffice to notice two of these—*Julus* and *Polydesmus*.

Julus comprises those forms with a smooth cylindrical body of 30 or more segments. The most injurious species is *Julus pulchellus*, Leach (sometimes known as *Blanjulus pulchellus*). It is a small, slender millepede, about ½ in. in length when full grown; in colour it is yellowish, with a row of crimson or purple spots along each side, a character by which it may always be recognised. A second common species is *J. terrestris*, *L.*, a larger millepede of a leaden black colour with whitish legs.

The species of *Polydesmus* differ from those of *Julus* in having only 20 segments to the body and in being rather broad and flat. The sides of the body are not smooth as in *Julus* but, owing to projections from each segment, appear to be notched. The most common species is *P. complanatus*, L., which, when adult, is about 1 in. in length. and varies from a pale purplish white to a dull red or brown colour.

Life-History.—The life-history of *Julus terrestris* has been described as follows:—Breeding takes place in May, June, and July. The female, when about to lay eggs, burrows down into the soil and forms a kind of nest from grains of earth glued together with saliva. The nest is like a hollow sphere, smooth inside but rough externally, and until the eggs are laid a small hole is left at the top. From 60-100 eggs are placed inside the nest, and the opening is then blocked up. The eggs hatch in about 14 days. The young millepedes at first have only three pairs of legs, the others appearing in groups by degrees. Growth in a millepede takes place by lengthening at the hinder end, the

increase occurring between the last segment and the one before it.

Plants Attacked.—The food of millepedes is almost entirely of a vegetable nature. Roots, bulbs and tubers of all kinds are attacked, and, when the animals are numerous the resulting damage may be considerable. There is nothing very distinctive in the form of injury produced, and the best method of diagnosis is the discovery of the millepedes themselves. In the case of *J. pulchellus* the millepedes may often be found in a cavity in the root or tuber, which is gradually eaten away. A millepede frequently extends an injury that has already been commenced by slugs or other agencies. In the case of an attack by one of the larger species an examination of the soil near the injured plant, or of any rubbish close by will often reveal the offender. It should be noted, however, that in all cases of attack a certain amount of decay is produced which attracts other enemies, and the identity of the original offender may be thus obscured.

Preventive and Remedial Measures.—1. Care should be exercised in the use of fresh leaf mould and decaying vegetable matter, which frequently contain millepedes.

2. Millepedes may be trapped by placing just under the ground mangolds, beets, or turnips the interior of which has been scooped out. The traps must be examined at frequent intervals and the millepedes collected and destroyed.

3. If powdered naphthalene is available, it is worthy of trial and may be used at the rate of 1-2 oz. per square yard. Its effects appear to be greater if the soil is watered after the application.

4. Dressing the ground with lime is a useful measure to employ against millepedes. A mere light top dressing is, however, of little use. The application should be heavy, and the lime, in a finely divided condition, should be thoroughly incorporated with the soil to a depth of a least one " spit " (8-12 in.).

5. It has been observed that if the drill destined to contain seed of peas and beans be well dusted with superphosphate of lime the seeds will remain immune from attack. Culturally, there is also the advantage derived from the employment of this manure, which will assist the plant in growing away from the attack.

It has been suggested that this recommendation may persuade farmers to drill superphosphate with peas or beans, a procedure which under certain circumstances appears to have caused serious injury. It may, therefore, be pointed out that this measure is only intended for application under

garden conditions, in which a "drill" is first taken out of the soil and the seed subsequently sown. No harm has yet been reported from the use of the measure in this manner, but in view of the results under farm conditions some caution is desirable, especially if the seed is to be sown in very dry soil.

MUSTARD BEETLES

(*Phædon cochleariæ*, Fab., and *Phædon armoraciæ*, L.).

Mustard, when grown for seed, is a speculative crop, and one of the chief reasons for this is to be found in its liability to the attacks of the small blue beetles known as "Mustard Beetles." While mustard, perhaps, suffers most frequently, the beetles also attack other plants of the cabbage family, notably cress when grown for seed, watercress, turnip, rape and cabbage, the three latter chiefly when in proximity to affected mustard fields. Mustard beetles are found throughout the British Islands and are widely distributed on the Continent of Europe. There are four closely allied species, but this leaflet is concerned with the most abundant, *Phædon cochleariæ*, F., in company with which is sometimes found a second species, *P. armoraciæ*, L.

Description and Life-History.—The adult Mustard Beetle is a bright, shining blue insect about ⅛ in. in length and of the general shape shown in Fig. 1. The adult beetles pass the winter hidden in mustard stubble or straw, among rough grass in dykes or hedge sides, under bark, or in any heap of refuse. They are, however, specially fond of the hollow stems of the mustard, both stubble and straw. In spring they leave their winter quarters, and as soon as the young mustard crops show the "rough leaf" the beetles collect on them, flying perhaps for some considerable distance if they are unable to find food near at hand. On reaching the mustard the beetles feed to some extent on the foliage but at first they are seldom present in sufficient numbers to cause any conspicuous damage. Small yellow eggs are laid on the undersides of the leaves at any time during the months of May and June. From the eggs are hatched small grubs which at first are yellow and later yellow spotted with black. These grubs feed for 2-3 weeks on the mustard leaves, and when about ¼ in. in length are full fed and drop to the ground, where they burrow into the soil and change to yellow pupæ. In ten days these pupæ turn to beetles, which crawl up from the soil and again attack the mustard leaves. Eggs are laid and from them are hatched grubs of the second generation, which feed rapidly and

become beetles from the end of July to the beginning of September; these beetles then feed for a time voraciously on the ripening mustard crop until it is cut, when they begin to seek their winter quarters.

Nature of Damage.—1. While it is obvious from the life-history that the beetles damage the crop throughout the growing season, the first brood is seldom sufficiently numerous to cause serious loss. The grubs and beetles of the second brood, however, are far more abundant, and not infrequently bring about the complete destruction of the crop. When the second brood grubs are feeding, the flowering period of the crop is usually just passing, and from then onwards it is a race between the crop and the beetles. The grubs first devour the leaves, and in this they are assisted by the adult beetles, which soon appear, until there may be no leaves whatever left. The beetles then feed on the " bark " of the stems, and if they do so to an appreciable extent before the seed has matured, the crop will be totally lost. In any case the destruction of the leaves will prevent the development of many of the later flowers, but unless the stems are " barked " it is probable that some crop, at all events, will be obtained. The race between the crop and the beetles is often very close, and a week's delay in the ripening may make the difference between success and failure.

The damage to other crops is essentially similar to that caused to mustard in that it consists in the destruction of the plant by the larvæ and the beetles. The attacks on cabbage, turnip, rape, &c., however, usually occur in districts where mustard crops are suffering or have suffered very greatly. In bad attacks on mustard the beetles may have nothing left to eat by the end of July, and then, if there are turnip or cabbage crops near, the pests are likely to migrate on to them in order to complete their feeding before going into winter quarters. Similarly, if the stubble of an infested field has remained unburnt, or the dyke sides around it have not been cleaned out, multitudes of beetles will emerge in the spring, and if they find a field of rape, cabbage, &c., near at hand are likely to destroy it. In the case of cress, the attack almost exactly resembles that on mustard, and the beetles may also cause serious injury to watercress if it cannot be subjected to flooding.

Natural Enemies.—Mustard Beetles seem to be fairly free from the attacks of insect enemies. Birds, however, notably starlings, at times devour them freely.

Methods of Control.—1. It is of the utmost importance that mustard stubble be harrowed up and burnt as soon as possible after harvest. The grass in the dykes and ditches

Photo, R. C. Maltby.

FIG. 1. Stems and seed heads of mustard plant (considerably reduced in size), showing barking of the former and damage to the later.

INSET.—Photograph of Mustard Beetle (*Phaedon cochleariae*, F.) much magnified.

around fields which have suffered should also be burnt. Hedge bottoms, equally, should be cleaned and all dead leaves burnt. Mustard straw presents a more difficult problem, as it has a small commercial value. It is probably good policy to burn it also in spite of the loss, but in any case it should be disposed of in some way before the spring.

2. Owing to the rapid growth of the crop and its nature when full grown, treatment by spraying can only be carried out early in the season; and the object, therefore, must be to kill the beetles and grubs of the first brood and so to check the production of the more dangerous second brood. It is not of course possible early in the season to predict with certainty whether there will be sufficient second brood beetles to cause damage or not; but regarded as a preventive, spraying is said to have given good results. Paris green and lead arsenate ought both to be effective, but it is reported that the former has proved more deadly. Either wet or dry spraying might be employed, but the latter is rather dangerous when using such poisons as Paris green or lead arsenate. In either case the spray should be applied as much to the undersides of the leaves as possible; in wet spraying the work should be done in dull weather and with a nozzle giving a mist-like spray. Formulæ for Paris green and lead arsenate washes are as follows:—

(*a*)	Paris green paste	1 oz.
	Quicklime	4 oz.
	Water	10 gallons.

The lime is slacked and then added to the water. The Paris green is worked with a little water into a "cream" which is also added to the water, and the whole is mixed.

(*b*)	Lead arsenate paste	8 oz.
	Water	10 gallons.

The paste should be worked to a "cream," with a little water, and the remainder then added to it.

In connection with lead arsenate and Paris green spraying, it should be understood that the grubs and beetles are only killed when they eat the sprayed leaves. Wetting the beetles with the spray fluid does not affect them.

3. Various machines have been invented for catching the beetles. They usually consist of shallow metal trays suspended from an axle with a wheel at each end. The trays are just wide enough to pass between the rows an inch or so from the ground, and they are joined at the top by sacking or other material, which sweeps the tops of the plants. Tar or paraffin is placed in the trays and the whole apparatus is pushed by two handles. The beetles are thus swept off the mustard plants and fall into the trays, from which they must be cleared at intervals, the tar and paraffin being renewed. Enormous numbers of beetles can be caught by machines of

this type; but they can only be used when the crop is about a foot in height and must, therefore, like spraying, be employed as a preventive (the work being carried out as a matter of routine in order to prevent the production of an excessive number of second brood beetles).

4. When a crop of ripening seed is being attacked some loss may be prevented by cutting earlier than would be advisable under normal circumstances. It is better to cut rather green than to allow the stems of the standing mustard to be "barked."

5. On farms where mustard seed is regularly grown, each crop should be sown on a field as far away as possible from that which has borne a crop the previous year. In any case it is wise to avoid growing the crop on the same farm for more than three years in succession.

NARCISSUS FLIES.

One of the most injurious pests attacking the bulbs of Narcissi and related plants is the Narcissus fly (*Merodon equestris*, F.). This insect, often known as "the Large Narcissus Fly," has been recorded in this country since 1869, and is now widely distributed in England and Wales, while it also occurs in many parts of Scotland and in Ireland. It is generally supposed to have been brought to England from the Continent, probably from Holland, but in the opinion of at least one authority it is considered to be native, and only to have become noticeable as a pest when daffodil growing became general.

Two other species of fly (*Eumerus strigatus Flor.* and *E. tuberculatus Rdi.*) which may be known as Small Narcissus Flies, are also pests of the Daffodil as well as of various other plants with bulbous or fleshy roots. These insects occur in the chief bulb-growing districts of the country and are also common on the Continent—whence they may originally have been introduced.

The Large Narcissus Fly.—The adult *Merodon equestris* (Fig. 1) is a large fly measuring about half-an-inch in length. The body is stout and very hairy, and the general shape is that of a small humble bee. In colour the individual insects vary considerably. The ground colour is black, but the hairs may be grey, yellow or brown, and the varieties, therefore, differ considerably from each other in appearance. The more common form is dark brown or black, banded with yellow or grey, when the fly much resembles a humble bee; in another form these bands are inconspicuous or absent, and the insect is very like a honey bee or a drone fly (*Eristalis*). Owing to

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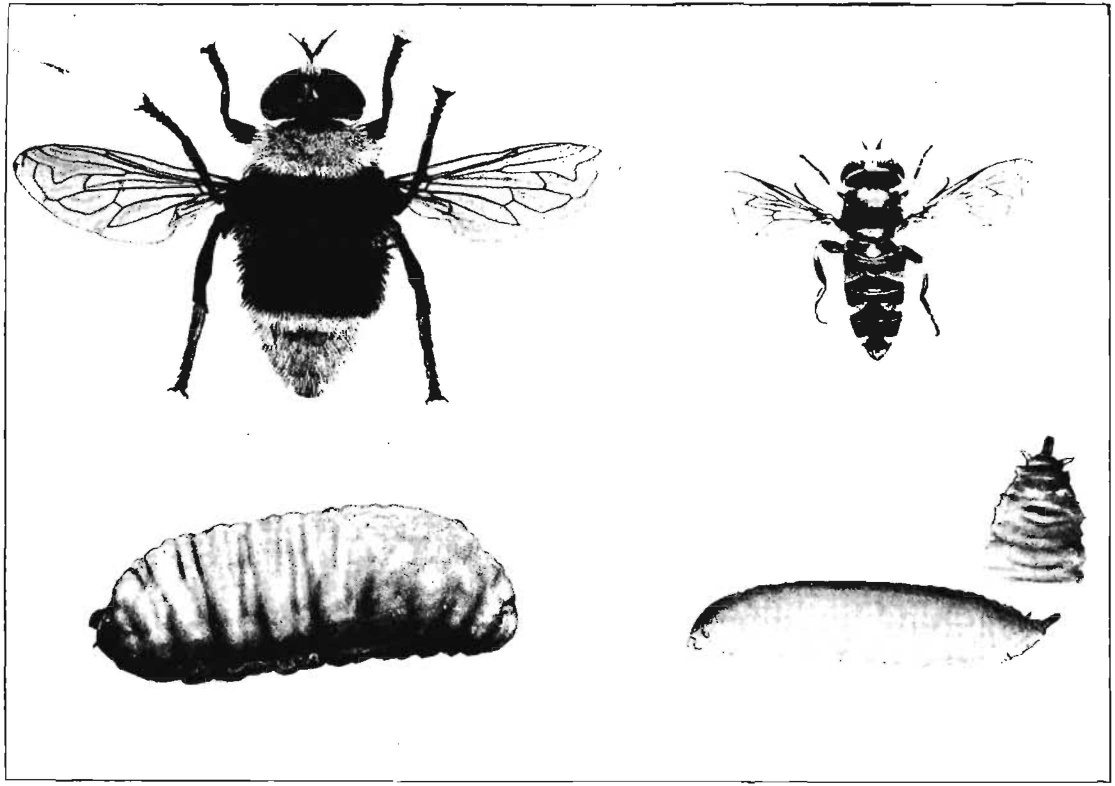

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FIG. 1.—Large Narcissus Fly (*Merodon equestris*).
FIG. 2.—Larva of Large Narcissus Fly.

FIG. 3.—Small Narcissus Fly (*Eumerus strigatus*).
FIG. 4.—Larva of Small Narcissus Fly.
FIG. 4a.—Posterior portion showing processes.

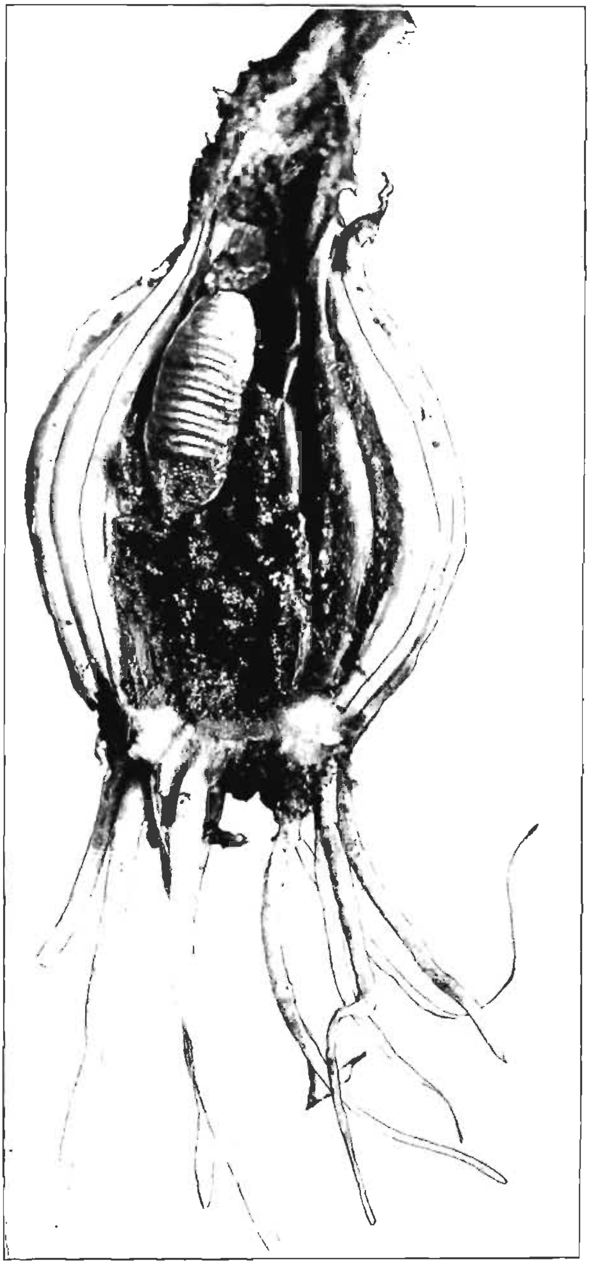

FIG. 5. Larva of Large Narcissus Fly (*Merodon equestris*) in a bulb.

this variation in appearance, bees, humble bees, and drone flies are frequently considered to be Narcissus Flies, and it may therefore be well to give the simple distinguishing characters. From either honey or humble bees *Merodon* may at once be distinguished by the fact that it possesses only two wings, whereas bees always have four. From drone flies it may be known by being more hairy and by possessing a broad tooth-like process on the underside of the femora (thighs) of the hind legs, near the tip. If a male it will also possess a sharp spur at the end of the tibia of the hind leg. Small Narcissus Flies have little resemblance to *Merodon* and are only about half the size (*cf.* Figs. 1 and 3), they are therefore not likely to be confused with it.

The egg of *Merodon* is minute, but visible to the naked eye; it is oval in shape and white in colour.

The *larva* is a legless grub of a whitish or yellowish colour, and when full grown measures from ½-¾ inch in length. Its general shape may be seen from Fig. 2. When first removed from the bulb it appears to be almost equally rounded at each end, but the hind end may be distinguished by a black horny projection, carrying breathing pores, which is almost withdrawn into the body. If the larva is left untouched for a minute or two it extends itself so that the front end becomes more pointed, and on its underside the mouth may be seen, with two minute black hooks representing the jaws. The black structure at the tail end becomes more obvious and a minute projection may be seen on each side. The larva of *Merodon* when full grown is not likely to be confused with other larvæ to be found in bulbs, but when young it might be confused with that of the Small Narcissus Fly, and the essential differences will be found under that species (page 69).

The pupa of *Merodon* is enveloped in a hard, horny skin, which is really the final skin of the larva; the black terminal projection can still be seen.

Life-History.—The flies are found in spring and early summer, flying actively in the sunshine. They then pair, and eggs are laid on the soil or leaves near the bulbs. It will usually be noticed that when the foliage has died down, a hole formerly fully occupied by the stalk and leaves, is left, leading down to the bulb, and advantage is taken of this by the female fly, which backs down the hole into the earth and deposits an egg on the soil or dead leaves close to the bulb. Although not wholly proved, it appears that the resulting larva passes down on the outside of the bulb and enters it in the region of the basal ring which bears the rootlets.

Once inside the bulb the larvæ feed steadily, consuming the whole interior until full grown, when they are often found in the hollowed-out neck of the bulb.

The majority feed rapidly and are full fed in the course of the autumn, when some pupate, though most appear to

remain in the larval state until early spring and then become *pupæ*. It is also said that larvæ may take two years to become full-grown, a view which is based on the fact that young larvæ have been found in the early months of the year. Since, however, flies have been observed as late as July it is probable that these small larvæ would still have time to complete their feeding in the spring and produce flies late in the season. As a rule only one larva occurs in each bulb, but two and sometimes three larvæ are occasionally found. The larvæ are able to migrate from one bulb to another in the soil.

The pupa is sometimes formed in the bulb, but more frequently in the soil.

Plants Attacked.—The bulbs attacked include the Narcissus, Hyacinth, Tulip*, Amaryllis, Habranthus, Vallota, Galtonia, Scylla, and Leucojum. As regards Narcissus it has been considered by a leading grower and authority on *Merodon* that the hard bulbs of the *N. maximus* and *N. spurius* type are least attacked, while the most susceptible are the *N. poeticus* and *N. Leedsi* varieties, and, further, that varieties with coloured cups are more susceptible than those without.

Nature of Injury.—The interior of the bulb is hollowed out, a wet mass of frass and decayed matter only remaining (Fig. 5). The decay due to *Merodon*, however, does not cause such a complete breakdown of the bulb as in the case of an attack by *Eumerus*.

When the larvæ are large the infested bulbs can be detected after a little experience by gently pressing near the neck with the fingers—sound bulbs being hard, and infested bulbs less resistant. When the larvæ are young it is much more difficult to be sure of their presence, but it is said that any bulb in which the basal ring is incomplete or damaged should be regarded with suspicion.

Methods of Control.—(1) It has been found by experiment that immersion of bulbs in hot water for one hour at a temperature of 110° F. is fatal to the larvæ of Narcissus Flies This investigation has been carried further and developed also in the direction of eelworm control.† As the latter is the more serious pest and most difficult to kill, the treatment found efficient for its eradication may be adopted as a combined measure for both eelworm and Narcissus Fly larvæ. This consists in soaking the bulbs at a temperature of 110° F. for 3 hours. No damage is done to the bulbs if they are in the right condition for treatment, which is the case when they have ripened off in July, August and September. A special apparatus for carrying out this treatment can now be purchased.

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* The Tulip is always mentioned as one of the food plants of *Merodon*, but it appears to be rarely attacked, and in badly infested localities Tulips are often quite undamaged.

† J. K. Ramsbottom, *Gardeners' Chronicle*, May, 1920.

(2) In the case of a small number of bulbs only, when gaps in the rows are observed early in spring, those which have missed should be searched for and destroyed.

(3) Bulbs which have the basal ring (from which the roots proceed) entire, are usually free from *Merodon* larvæ, but if this ring is found to be broken and incomplete the presence of larvæ may be suspected and such bulbs should not be planted unless they have been first treated as above.

(4) Bulbs should not be left for too many seasons in the ground but should be lifted periodically in summer and all those found to be infected should be destroyed or treated.

(5) Owing to the egg-laying habits of *Merodon* and the favourable position of the bulb to attack after the foliage has died down, " earthing them up " or raking soil over the crowns in such a way that the holes leading down to the bulb on the withering of the foliage may be filled up is a simple measure tending to prevention that may be worth a trial.

Small Narcissus Flies.—The adult *Eumerus strigatus* is a fly about $\frac{1}{4}$ in. in length, the general appearance and shape of which is shown in the plate (Fig. 3). The general colour is black, but between the wings the thorax shows greenish metallic reflections, and there are white crescent-shaped marks along the sides of the abdomen, and a white line on each side of the thorax.

A second species *Eumerus tuberculatus* which has hitherto been confused with *E. strigatus* has recently been discovered. The two species are exceedingly alike and for all practical gardening considerations they may be taken together.

The larva of Eumerus is a legless grub of a yellowish white colour, though it is usually stained dark brown by the decaying material in which it lives. When full grown it measures from $\frac{1}{4}$ in. to $\frac{1}{3}$ in. in length. Its most marked characteristic is the possession at the tail end of a conspicuous chestnut-coloured horny tubercle, on each side of which is a pointed projection which is also easily seen (Fig. 4a). These characters will serve to distinguish the *Eumerus* larva from that of *Merodon* at all ages, and from any other larvæ which might be found in bulbs. The fact that there are always a number of larvæ (usually 10 to 30) in attacked bulbs will also help to determine the presence of this species, but it must be remembered that both *Eumerus* and *Merodon* may be found in the same bulb.

The pupa is barely $\frac{1}{4}$ in. in length and is enclosed in a hard, horny skin of a whitish colour. As in the case of *Merodon*, this skin is really the last skin of the larva and shows the marked characteristics mentioned above. It is usually found under the outer scales of the bulb, or in the neck, but may also occur in its interior or in the earth near the bulb.

Life-History.—The flies appear in May and June and deposit eggs after the manner of *Merodon*, with the following exceptions :—(1) large numbers—up to 40—are deposited in a mass, and (2) owing to the small size of the fly, the female is able to crawl right down the hole left by the withering of the leaves and so lay her eggs on or very close to the bulbs.

The eggs hatch and the larvæ burrow into the necks of the bulbs. Of these larvæ, some appear to feed rapidly and are full grown in August, when they pupate and produce flies in September and October. The remaining larvæ become full grown in the autumn and as a rule remain as larvæ until early spring, when they pupate, producing flies in late spring and early summer. What becomes of the flies which emerge in autumn is not yet known, but they do not appear to live long and almost certainly do not hibernate. Specimens have been observed pairing in September and October. In certain experiments bulbs in the ground and also uncovered in the store were exposed to flies of the second brood but were in no case attacked. The flies themselves may be found flying in the sunshine over the Narcissus beds; they do not seem to go far from the plot from which they have emerged, and fly close to the ground, often settling on the soil. They were not observed to frequent flowers.

Plants Attacked.—The Narcissus is most often attacked, but now and again the grubs have been found not only in many other kinds of bulb but also in the rhizomes of Iris and the roots of Parsnip. On the Continent, Onions and Shallots appear to suffer considerably. The fact that onions in Britain are not known to be damaged by the pest suggests that the Continental onion seeding "Eumerus" may belong to a species not yet resident in England. It is not yet known whether either of the two English species has any definite preference for any special kind of bulb or root.

Nature of Damage.—In an advanced stage of the attack the interior of the bulb is entirely destroyed, and is full of a semi-liquid decaying mass. The attack seems to begin at the neck, and in mild cases the larvæ are found in the neck or under the scales at one side. The presence of many larvæ and the complete decay produced distinguishes the damage done by *Eumerus* from that done by *Merodon*.

Methods of Control.—The treatment advised for *Merodon* is also effective against *Eumerus*.

It has been suggested that the Small Narcissus Flies prefer bulbs which are already diseased or decaying, and this appears to be to some extent the case. It is nevertheless true that the female flies lay their eggs on perfectly sound bulbs and they must therefore be regarded as true pests as well as scavengers.

Other Flies.—The larvæ of several other flies are frequently found in bulbs decaying from any cause, but they do not appear ever to start an attack on a healthy bulb.

The commonest species are *Lonchæa chorea*, of which the fly resembles a small " blue-bottle "; and species of *Scatopse* and *Sciara*, these being small gnat-like insects.

THE ONION FLY

(*Hylemyia antiqua*, Meigen syn. *Phorbia cepetorum*, Meade).

The Onion Fly is widely distributed throughout the country and is a serious menace to small and large growers alike. The pest is so plentiful in parts of Lancashire, notably those districts in the vicinity of large towns. that it has become impossible to grow onions at all. The fly occurs also in Canada, in the United States and on the Continent of Europe.

Plants Attacked and Nature of Injury.—The onion is the plant usually attacked in this country, but it is not uncommon to find leek and shallot infested, while in Italy garlic is a frequent victim.

It is in the spring and early summer that the worst damage occurs. The plants are then small seedlings, and are devoured extensively by the fly maggots. These occur in large numbers, and migrate from onion to onion completely destroying all the underground portion of each.

If the attack does not develop until later in the season, when the onions have reached some considerable size, the first indications of the infestation are usually a yellowing of the longest or first leaves of the plants. These subsequently wilt and turn a whitish colour, and if pulled will easily break away from the stem, the whole top eventually dying and falling to the ground. Sometimes the outer leaves are found lying on the ground, still green, while the leaves remaining upright and green feel soft and flabby. The bulb is invariably rendered useless for human consumption. and in bad cases is reduced to a rotting semi-liquid mass.

If infested plants are examined it will be noticed that young plants are generally nearly eaten through by the maggots just above the swelling bulb. In older plants maggots of all sizes may be found within the bulbs themselves. Any number of maggots from three to thirty may be found in one bulb; they usually enter the onion at the base and work their way upwards, but may sometimes enter the side of the bulb.

Description and Life-History.—The adult fly is grey, with four, more or less distinct, brownish stripes on the thorax.

and a series of dark triangular marks on the abdomen. In general shape and appearance it somewhat resembles the common house fly.

The flies first appear in spring and early summer, and after about a week lay their eggs on the young leaves or necks of the onions, or in the soil near by. The eggs are white, oval in shape and about 1/20th inch in length. The eggs hatch, generally after three days, and the maggots (larvæ) immediately burrow through the soil to the roots of an onion, and, boring their way in through the base of the bulb, commence to feed. These maggots are dull dirty white in colour. The head end is pointed and has a pair of black hook-like jaws. The tail end is blunt with projections round the hind margin and two brown spots (spiracles) in the centre. The maggots become full grown in about three weeks and are then about ⅓ inch long. They leave the onion, burrow in the soil to a depth of 2 or 3 inches and turn into oval-shaped puparia, chestnut brown in colour. From these puparia adult flies hatch out after about seventeen days in summer, but those pupating in autumn remain in the pupal state until the following spring. There are apparently three main broods during the season in this country, but these overlap and merge into each other.

Natural Enemies.—There are two known natural enemies of the Onion Fly in this country. One is a Braconid, *Aphaereta cephalotes*, Hal., which emerges from the puparium, the eggs being almost certainly laid in the maggot before it pupates.

The other is a Staphylinid or " Rove " beetle, *Aleochara bilineata*, Gyll. The larva of this insect feeds upon the Onion Fly pupæ, finally pupating in the skin of one of its victims whence it emerges as an adult beetle.

Methods of Control.—The Onion Fly is a most difficult insect to control. Attacked plants should, of course, be burned as soon as possible in order to avoid the production of further broods, and, in removing badly decayed plants, care is needed or many larvæ or pupæ will be left in the surrounding soil. After a crop has been attacked it is obvious that in the following year onions, if grown at all, should be sown as far away from the infested land as possible. There are indications that Onion Flies are attracted to fresh manure: in affected districts it would therefore be a wise precaution to manure plots intended for cropping with onions some considerable time before sowing.

1. *Early Planting.*—Any measures which will bring the plants forward early in the season will reduce the injury done by the fly. To this end young immature bulbs which have been stored through the winter may be planted out in spring, or, alternatively, seeds may be sown in autumn or

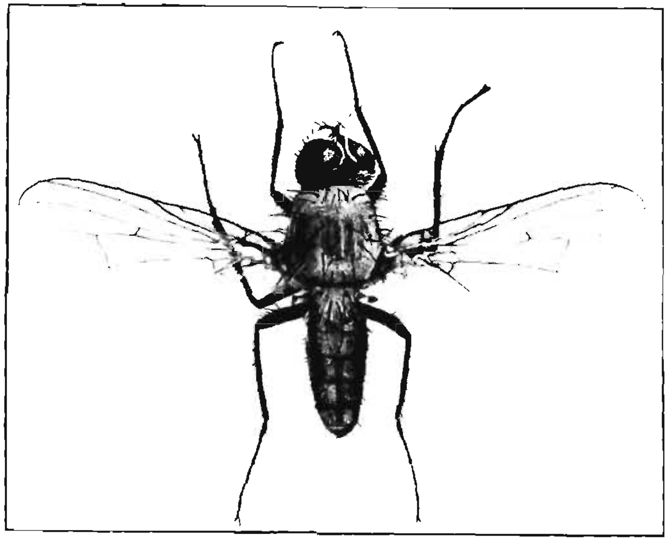


FIG. 1.

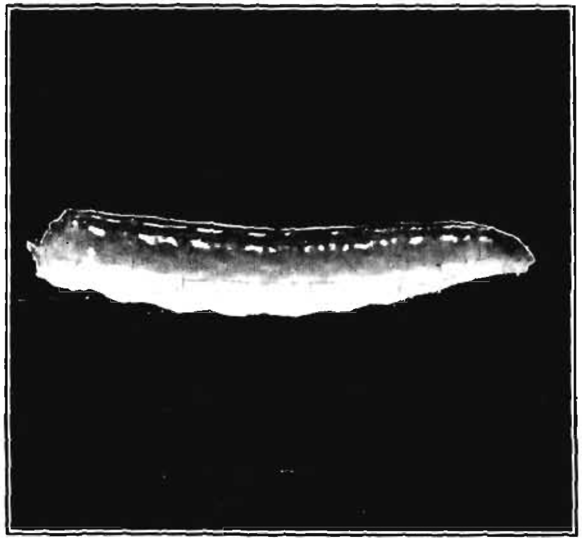


FIG. 2.

FIG. 1. Adult Onion Fly.

FIG. 2. Larva of Onion Fly.

FIG. 3.

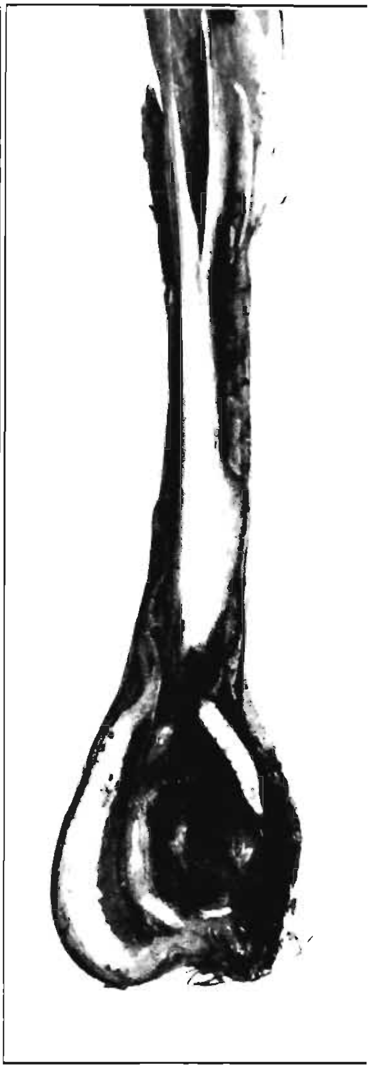


FIG. 4.

FIG. 3.—External appearance of attacked onion.

FIG. 4.—Attacked onion cut down the centre to show larva.

under glass in January or February, and the young onions pricked out in April. Manures such as nitrate of soda or sulphate of ammonia are useful in stimulating rapid growth.

2. *Dressings.*—Various dressings have been used with some success to deter the flies from egg laying. It is essential to apply them before the egg laying commences as they are useless once the maggot is in the onion. The applications should be repeated at intervals of two or three weeks.

According to Smith* the following mixture has proved most efficacious: Green tar oil, 1 part by weight of the chemical to 99 parts by weight of precipitated chalk (approx. ¼ oz. to every 1½ lb. chalk); the two should be well mixed together and dusted over the plants by hand or with a powder sprayer at the rate of 2½ gal. of the mixture to each sq. rod (or 30 sq. yd. approx.).

3. *Emulsion Sprays.*—Paraffin emulsion* may also be used with some success (paraffin 4 pints, soft soap 1½ lb., water 10 gal.). Dissolve the soap in 1 gal. of boiling water, add the paraffin and churn up till emulsified, to attain which state the best method is to spray the mixture back into itself with a hand syringe. When required for use add the remaining 9 gal. of water and again stir thoroughly. Carbolic acid emulsion and suspensions of hellebore and pyrethrum are used in Canada and the United States with some effect. The liquids are applied to the plants and the soil round them; either by means of a spraying machine with a coarse jet or a watering can with a narrow spout.

4. *Poisoned Syrup.*—Experiments in America appear to show that the female flies are strongly attracted by a mixture of treacle ("Molasses") and water. The resulting syrup, poisoned with sodium arsenite, is therefore sprayed on the plants or is exposed among them in tins or pans for the flies to drink in order to kill them before they have laid their eggs. The poisonous nature of the syrup does not render its use desirable under English conditions, but the substitution of a less dangerous insecticide than the arsenite would be worth a trial.

5. *Planting with Parsley.*—An old-fashioned preventive measure against Onion Fly attack is to plant parsley between the rows of onions with the object of masking the scent of the onions by that of the parsley.

PEA AND BEAN BEETLES.

If a few samples of horse beans, broad beans or kidney beans be examined, it is almost certain that seeds will be

* Insect Pests of the Horticulturist: Onion, Carrot and Celery Flies, Chapter III, 1922.

found containing a round hole or burrow. The same, though less frequently, may be observed in peas, and it is also a very common feature in imported food pulses such as lentils. These holes are made by one or other of a number of kinds of beetles, which are usually known as Pea or Bean Beetles—also, but quite incorrectly, as Pea or Bean Weevils, a name which should be reserved for the insects which are so destructive to the first-formed leaves of seedling peas or beans (*see* Leaflet No. 19 included in this volume).

Although several kinds of pea and bean beetle are commonly found in Great Britain, there is perhaps only one, the Common Bean Beetle (*Bruchus rufimanus*, Boh.) which is a permanent resident and would persist in our gardens or fields without continual introductions from abroad. The second kind, the Spanish Bean Beetle, known to English collectors as *B. affinis*, Fröh., but perhaps really a large race of *B. rufimanus*, is annually introduced on bean seed, *e.g.*, Seville Long-pod, from the Mediterranean countries, but it does not seem able to establish itself permanently. The third species, the American Bean Beetle (*Bruchus obtectus*, Say.), occurs in imported bean seed from tropical and warm countries.

As regards peas, the Pea Beetle (*Bruchus pisi*, L.) is a fairly common insect, especially in warehouses where imported peas are stored; although it is usually regarded as an English pest, it is very doubtful if it could maintain itself without continual re-introduction on seed peas from warmer climates.

Plants Attacked and Nature of Damage.—The only plants of value concerned are peas and beans, although insects allied to those mentioned above attack the seeds of broom, wild vetches, &c. All forms of horse or tick bean and broad bean are subject to the Common Bean Beetle; kidney and French beans are infested by the American Bean Beetle, but this does not seem to apply to home-saved seed. Such varieties of broad bean as the Seville Long-pod, mentioned above, are attacked by the Spanish Bean Beetle, but here again as the insect does not seem to flourish in the English climate, home-saved seed escapes injury. The only species attacking peas is the Pea Beetle mentioned above.

In regard to the actual loss caused by these pests and so far as garden or vegetable crops are concerned, the injury relates solely to the loss in power of germination caused by the burrowings of the pest in the seed. In such large seeded varieties as the broad bean, the actual reduction in germination appears to be slight, since the germ is very seldom damaged. Even a badly infested sample of broad bean may be sown and the crop, notwithstanding, may prove perfectly satisfactory. From this it must not be argued that it is wise to sow a badly infested sample, since it is likely that, when the seed has become softened in the soil, the holes made by

the beetles will act as points of entry for such pests as millipedes, &c. In regard to the smaller bean seeds, kidney and French beans for instance, the case is different. Then the attacks of the beetle reduce far more, in proportion to the larger seeds, the amount of food nourishment available for the seedling and, as a result, the ensuing plant is likely to be weakly. In an experiment with " Canadian Wonder " beans attacked by the American Bean Beetle, it was found that beans *showing one hole only were nearly as good as beans that had not been attacked, but where the seed had been infested by more than one beetle, the loss was very considerable and in* some cases the bed resulted in total failure.

Thus in the case of garden beans generally, it may be assumed that the larger the seed, the less harm will result from the attacks by the Bean Beetle, while the smaller the seed, the greater the injury which may be expected.

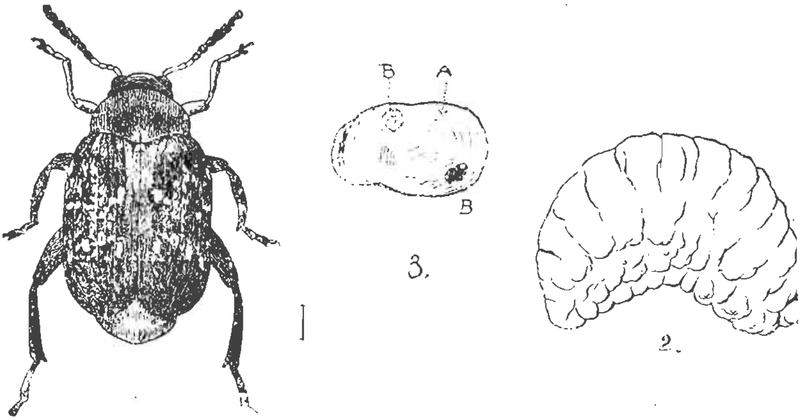
In the case of horse beans, again rather a small seed, there is the reduction of germinating power and the likelihood of the holes permitting the entry of pests, but, in addition, the possibility of the resulting crop being similarly attacked, with a loss in weight when harvested.

In this connection, it may be mentioned that samples of beans were taken from a field in which approximately 25 per cent. of the crop had been injured by the Common Bean Beetle. By weighing the infested seeds and the sound seeds, it was possible to obtain some estimate of the actual loss in weight due to the insect, and this worked out at about 4 per cent. From this it may be assumed that though the insect is not perhaps of first importance, nevertheless, anything which can contribute towards the growing of beetle-free crops is worth attention, both to obtain a strong plant in the first instance and to avoid a small though definite loss in the weight of the threshed beans.

Description and Life-History.—The adult beetle is a small black, brown and grey insect as pictured in *Fig.* 1. All kinds resemble each other more or less in shape, but the Spanish Bean Beetle is somewhat larger than the others, while the American beetle may be known by its small size and brown colour. The Pea Beetle is characterised by its speckling with black and white.

The habits of the Spanish and the Common Bean Beetle and the Pea Beetle are very similar. The adult beetles spend the winter either still within the pea or bean seed or else in any shelter out of doors and in the warehouses in which the seed has been stored. With the advent of summer they fly out, and, as soon as the pea or bean crops are in flower, the females lay an egg on the young pod almost before the flower has dropped. From this egg comes a small active larva, which burrows in through the pod and into the developing seed.

Within the seed it becomes a maggot-like creature which continues to feed until it is full grown, usually towards the end of summer. It then turns into a pupa, still within the seed, and from this pupa a little later comes the adult beetle, which, as has been mentioned above, may remain within the seed for the winter or may come out and shelter elsewhere. If the beetle is still within the seed, it is possible by close attention, to discover a round circular spot where the skin



COMMON BEAN BEETLE (*Bruchus rufimanus*).

1. Adult Beetle; 2. Larva; 3. Attacked bean.
A. Hole covered by skin, insect inside.
B. Empty holes from which beetles have emerged.

of the seed has been almost bitten through so as to enable the insect to escape. This thin covering is pushed away by the beetle on leaving, and, as a result, the seed shows the round hole which is so characteristic. It will thus be seen that, where seeds are noticed with a hole in them, the beetle has already escaped. It is also worth repeating that the beetle grubs, when feeding, usually neglect the germ of the seed, so that it is seldom that attacked seeds are prevented from germinating.

The American Bean Beetle differs from those mentioned above in one important particular; it is able to attack dry beans in the store provided they have been slightly injured or have previously been infested. The American Bean Beetle is an insect originally of tropical or sub-tropical climates, and it is by no means certain yet that it will be able to persist out of doors in Great Britain. At the same time this capability of breeding from generation to generation in dry beans renders it likely to become a pest of some importance in warehouses storing beans, and it is an insect deserving of special attention by seedsmen, if not by nurserymen and gardeners.

Natural Enemies.—There is little evidence to show that any of the insects dealt with in this leaflet are much subject to the attacks of birds, but it is not infrequently observed that the insects within the seeds have been killed when in the grub stage by a small "ichneumon" fly (chalcid). The extent, however, to which this natural control persists is at present unknown.

Methods of Control.—1. It is not desirable that seed *actually containing living beetles of any of the species above* mentioned should be sown. By so doing the insect is enabled to escape and will continue to cause injury during the following year. Seedsmen do not, as a rule, sell seed actually containing a living insect, but, when samples are bought in this condition, the seedsman should be requested to disinfect the seed prior to delivery.

2. The insects may be killed within the seed by fumigating either with carbon tetrachloride or with carbon bisulphide. The seed to be treated, if large in quantity, should be placed in a tank or a wooden cask, the top of which can be made reasonably air-tight. The infested seed is placed within the tank or cask and a pad of folded sacking is placed over the top of the seed. The chemical, at the rate of ½ lb. per 50 cubic feet of the container in the case of carbon tetrachloride, and ¼ lb. per 50 cubic feet in the case of carbon bisulpbide, is then poured on to the sacking and the lid of the tank or cask fixed securely down. Fumigation is allowed to continue for 36-48 *hours; the lid is then removed and the seed spread* out on a floor to air. The insects are killed by this treatment and no damage is done to the seed. In the case of either fumigant, disinfection should be carried out in some shed in the open, away from main buildings. Since carbon bisulphide is dangerously inflammable, care should be taken that no lights of any description are brought in proximity to the shed. Carbon tetrachloride is not inflammable, but, although it is not highly poisonous, care should be taken not to breathe the fumes *more than* is *absolutely* necessary, and for this reason it is better to do the work in an open shed. The same method of disinfection could be employed in the case of small quantities of seed, which may be enclosed in a bottle or any other air-tight container, but the precautions as to danger from fire and as to not breathing the fumes must be regarded as closely as if a large quantity of seed were under treatment.

In fumigating bean seed, success is to some extent dependant on the temperature and, whenever possible, it is preferable to *fumigate at a time when the temperature exceeds* 50° F., while 75° F. is said to be better.

3. Where a pint or so of bean seeds are found to be infested by living beetles, it is not difficult to go over them and to pick out all seeds showing the dark or semi-transparent spot through which the beetle will ultimately emerge. Once

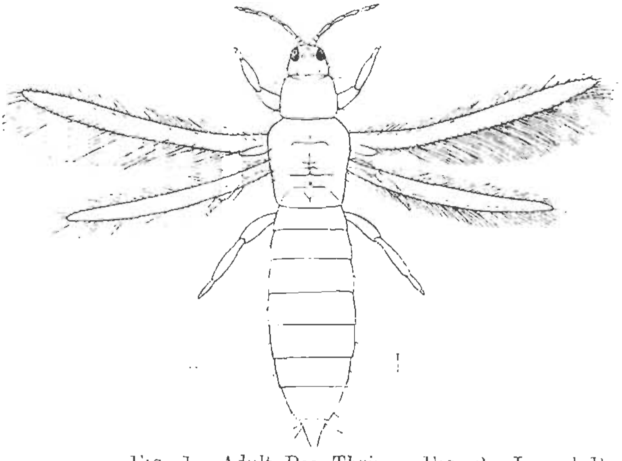
this spot has been found, it is quite easy to kill the beetle underneath by means of a pin.

4. It is said that the insects in infested peas or beans can be killed by dipping the seed for 5 seconds into water which is almost boiling. In this case the insects are reported as being killed without any injury to the seed. However, this method cannot be recommended, since any slight error in prolonging the time of immersion in the water will destroy the power of germination, while if the period is too short the insects will not be killed.

5. In a previous section notes have already been given as to the results which are probable from sowing infested seed. They may be summarised as follows:—In the first place, sound seed is in all cases preferable to seed which has been attacked. In the case of large seed such as broad beans, the difference between attacked and unattacked seeds is comparatively slight and the latter can, if necessary, be sown with reasonable safety. This is especially the case with such varieties as Seville Long-pod, of which a sample can seldom be obtained showing no signs of injury. In the case of small seeded varieties, such as "Canadian Wonder," and of peas, it is preferable to avoid attacked seeds altogether, though in cases of real necessity, the grower need not despair of getting fair results from any seed which does not show more than one flight hole. This also applies to horse beans but if a bad sample must be sown, the rate of seeding should be increased to allow for failures.

PEA AND BEAN THRIPS

(Frankliniella robusta, Uzel).



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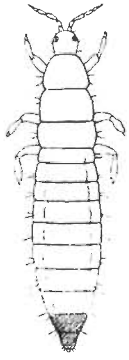

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FIG. 1.—Adult Pea Thrips. FIG. 2.—Larval Pea Thrips.

The small insects known as Thrips, or Thunder Fly, are extremely abundant in this country, and may be responsible

for considerable damage to cultivated plants. Species are known which attack cereal crops, others damage fruit, and there are several which are injurious to plants grown under glass. The insect dealt with in the present leaflet, *Frankliniella robusta*, was formerly known to science as *Thrips pisivora*. It has been recorded as harmful to peas and beans for many years, but since its life-history has been worked out, there is little doubt that in the past several species have been confused under one name. The group, as a whole, has been insufficiently studied, and much still remains to be discovered before our knowledge of these insects in relation to practical agriculture can be considered satisfactory.

Description.—The adult insects of the Pea Thrips cannot be distinguished from other species of Thrips without entering into minute features only to be observed under the microscope. They are small black insects about $\frac{1}{15}$ inch in length, elongate in form and tapering towards both head and tail, the latter appearing to be sharply pointed. They have four wings in the adult stage, each consisting of a narrow membrane surrounded by a broad fringe of hairs, which give the insects sufficient expanse of wing to enable them to fly or drift long distances. The general appearance of the adult Pea Thrips is shown by Fig. 1. The young Pea Thrips are somewhat like the adult in form but have no wings; they are bright orange in colour with a conspicuous black tip to the abdomen (Fig. 2), the latter feature serving to distinguish them from most other species likely to be found on peas and beans.

Distribution.—The Pea Thrips is distributed over the whole of England and is recorded from Ireland. The districts where most damage is done, however, are chiefly in the south and east of England, though records have been received occasionally from as far north as Cheshire.

Life-History.—The eggs of the Pea Thrips are laid in June. They are minute, kidney-shaped and are imbedded in the tissues of the stamen sheaths, young pods and, rarely, in the petals of the pea or bean flower. After about nine days they hatch and the small orange coloured young feed on the petals, stamens, and inner parts of the flower, and later on the pods. Their method of feeding is peculiar and consists in scraping away the surface tissues of the plant and then sucking up the liquid and minute fragments from the wound. After feeding for three or four weeks the Thrips leave their food plant and descend into the earth, where they remain quiescent for the rest of the summer, through the autumn and winter until the spring, when they pass through two stages, which together may be likened to the pupal stage of many

other insects. These two intermediate stages last about one month and the insects then become mature winged Thrips which leave the soil in May and June and go in search of pea or bean flowers on which to lay their eggs. The males emerge earlier than the females and are at first quite common, but before much damage is visible they have mostly disappeared and only females can then be found.

Plants Attacked and Nature of Injury.—The Pea Thrips here described is only known with certainty to attack the culinary pea and the broad bean. In the case of attacks on scarlet runner beans it is not known which species is responsible and it may possibly be one of which the life-history is still unknown. The damage done by the Pea Thrips is two-fold. In the first place the flower may be so injured that no further development takes place, and secondly when a damaged pod develops it has a curious silvery or shining appearance, more or less mottled with brown. Some distortion may also occur, but the appearance of the pod is the most characteristic feature of an attack. In this country injury to the haulms does not seem to be common, but it is known in Sweden and may frequently pass unnoticed here.

No satisfactory control measures for this pest have yet been devised.

PEA AND BEAN WEEVILS

(*Sitones* species, notably *S. lineatus*, L.).

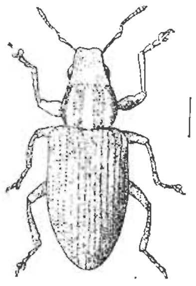


FIG. 1.—Bean Weevil.

FIG. 2. Damage to foliage of Pea Plant by Sitones.

Plants Attacked and Nature of Injury.—Peas, beans, clover, trifolium, vetches, and other leguminous crops are subject to the attack of the little *Sitones* weevils, often known as Pea and Bean Weevils. The chief injury is done to the plants when in the seedling or early stages, and, in the case of peas and beans, the damage is very characteristic as the

beetles eat out semi-circular pieces from the margins of the leaves, which in consequence present a peculiar notched appearance. Owing to the difficulty of finding the beetles themselves (which, when disturbed, readily fall off the plants and hide in the earth), gardeners sometimes attribute the injury to birds or slugs. In some districts in fact where the attacks occur every year, so familiar has become the appearance of the notched pea and bean leaves that it has proved difficult to convince growers that the injury is due to an insect and not normal to the plant! In an average year the young seedlings grow so rapidly that they are able to make more leaf than the weevils can eat and they therefore recover well from the attack, but if the plants receive a check or the beetles are unduly numerous, the leaves are eaten faster than they can be produced and then whole fields of peas, beans, &c., may be wiped out.

A second form of damage which is at present little known but may ultimately be found to be of importance is caused by the larvæ (grubs) of the weevils. These grubs feed at the roots of leguminous plants—peas, beans, clover, &c.—eating specially the nodules. It is quite possible that *Sitones* grubs may thus have been responsible for the unsatisfactory state of many crops although the cause of the injury has passed undetected.

Description and Life-History.—There are in Great Britain a number of kinds of *Sitones* weevil, many of which are so much alike that they can only be distinguished by the entomologist. The species most often found on peas and beans is the Striped Pea and Bean Weevil (*Sitones lineatus*) which is shown in Fig. I. It is a little beetle about $\frac{3}{16}$ in. in length, brownish in ground colour with lighter, often golden-brown stripes. Its under surface is greyish-brown and therefore when in the soil it is most difficult to see, no matter whether it is right way up or upside down. The other common species of *Sitones* (such as *S. crinitus*, Herbst; *S. hispidulus*, Fab.; *S. puncticollis*, Steph., and others) resemble the Striped Weevil fairly closely and need not be fully described. The exact part played by each species in the destruction of cultivated crops is not yet known nor are their exact habits and life-history. The life-history of the Striped Weevil has recently been investigated and may be summarised as follows:—

The characteristic damage (*i.e.*, notched edges) to the leaves of young pea and bean plants when two or three inches high in the spring is generally the work of the adult Weevils (*Sitones lineatus*) which have spent the winter in some rubbish heap or other convenient shelter. They pair and deposit eggs in the earth around the plants, continuing to do so throughout most of the summer. These

eggs hatch in three weeks, the young, footless, white larvæ burrowing down and into the nodules on the roots of the plants. As they grow they feed readily on these nodules and much damage is done to the root system of the plants. In about six or seven weeks the larva becomes full-fed and constructs an oval cell in the soil, an inch or two below the surface, in which to undergo pupation. The pupal stage lasts about 16 to 19 days, but after casting the pupal skin and becoming an adult weevil, the insect remains five or six days longer in the earthen cell until its external parts become hard and coloured. On emergence it takes to the leaves of the plants, forsaking altogether the roots amongst which its larval or grub stage was passed. Although the weevil feeds on the plants the damage at this time is comparatively negligible as the peas or beans have grown too big to be seriously affected. The serious damage which these newly emerged beetles will ultimately do will be in the following spring to the young plants; on these they will feed and lay eggs after their winter sleep, as did their parents before them, thus completing the cycle.

To recapitulate: The Striped Bean Weevil emerges from an earthen cocoon in the ground in July and onwards, feeds on the well-grown pea and bean plants until autumn when it goes into hibernation amongst rubbish, pea straw, long grass, &c. In March and April it appears again and does much damage by eating the young pea and bean plants. It pairs and lays eggs, the resulting grubs feeding upon the root nodules of the plants and turning to pupæ in earthen cells from which the beetles again emerge in July and onwards. There is thus but one brood in the year.

Natural Enemies.—There are three species of parasitic fly (Braconidæ) known to prey upon these weevils, of which one, *Perilitus rutilus*, Nees. is more destructive to them than the other two. They are also subject to a fatal fungoid-disease, *Botrytis bassiana*.

Methods of Prevention and Remedies.—1. *Garden Cultivation.*—As unbroken clods of earth provide the beetle with shelter, every effort should be made to obtain a good tilth.

Lime, soot, or lime and soot mixed, may be distributed over the plants, the application to be made, if possible, after a heavy dew or rain. Finely powdered guano has also been used in this way. An observer found that by covering rows of peas with fine earth the beetles were kept in check, and Theobald recommends that this treatment should precede the application of lime and soot. Powdered naphthalene and the various commercial soil insecticides are also worthy of trial against this pest.

Spraying has been found beneficial, both arsenical washes and weak paraffin emulsions being used for this purpose. Some difficulty has been experienced, however, in distributing the arsenical washes with sufficient uniformity over the leaves of the plants.

2. *Field Cultivation.*—A crop which is vigorous can often withstand an attack, as it will produce more foliage than the beetles can devour. Suitable cultivation in conjunction with liberal manuring therefore tends to prevent serious damage.

The recommendations as to lime and soot given in the preceding section for garden cultivation apply equally to field cultivation.

Insecticides other than soot and lime appear to have been little used against this insect, but where the grower has the necessary appliances they might certainly be tried.

The beetles hibernate in heaps of rubbish, at the bottoms of rank, overgrown hedgerows and in rough dyke sides. If all rubbish is burnt and hedgerows or dykes are well kept, this pest and many others which winter in the same way will be greatly checked.

SLUGS AND SNAILS.

The number of different plants which are eaten by slugs and snails is so numerous and, moreover, the damage done by them is so well known to all gardeners that any detailed description of plant or damage is rendered superfluous. Not only is havoc wrought in the kitchen, flower garden and allotment but also on the farm serious damage is repeatedly done to large acreages of wheat and oats and to potatoes grown under agricultural conditions. The aggregate amount of damage done by slugs and snails to cultivated plants and their seedlings every year must be very great, even in dry adverse seasons when the animals do not attain anything approaching epidemic proportions. During wet winters with mild weather extending into the spring, conditions which are specially favourable to slugs, these pests continue active and feed at a time when the foliage is small and vulnerable, causing heavy losses to cultivators.

The above remarks apply to certain very common species. There are others whose numbers and habits render them not only comparatively harmless, but in some cases even beneficial.

Slugs and snails belong to a class of animals known as *Mollusca*, a class as a whole more familiar under the name of shell fish, which it also embraces. Their structure, mode of

feeding and habits of reproduction are distinct from those of insects and require a separate consideration in connection with methods of control.

Slugs are separated from snails by the fact that the former carry no visible shell or, in some cases, one only apparent when searched for, whereas snails of all kinds carry a large, more or less spiral, structure in which the external parts of their bodies may be withdrawn when at rest.

Snails and slugs are both male and female in the same individual, pairing with one another and each laying eggs, thus being capable of extensive reproduction. Their mode of eating is by means of a long ribbon-like rasp drawn over a horny upper jaw.

The eggs of slugs and snails are round or oval, white, semi-transparent or opaque bodies, according to the species, deposited in the earth or other damp situation, such as under decaying vegetation.

Both slugs and snails feed chiefly at night, though after a shower following a dry spell they may make their appearance before darkness has fallen. Almost anything that affords a cool hiding-place gives harbourage during the day. Slugs, which often retire into the soil itself, continue feeding throughout the year when temperature conditions are favourable. Snails, on the other hand, hibernate, frequently in clusters, during the colder months in situations affording complete dryness, the aperture of the shell at this time being closed by a horny secretion forming a seal known as the épiphragm. They also protect themselves in a similar way during very hot weather in summer. A very important feature, possessed by both slugs and snails, is the power of excreting slime which both assists them in crawling and also enables them to get rid of any irritating substance which may fall upon them. It is this power which renders them so difficult to destroy.

The following is a short description of the slugs and snails usually met with.

Slugs.

The Garden Slug (*Arion hortensis*, Férussoc) is a small dark-coloured slug with a yellow foot and yellowish slime and a very tough skin, commonly found in gardens, where it does much damage to seedlings.

The Large Black Slug (*Arion ater*, L.) occasionally does damage near damp ditches and hedgegrows, but is not commonly harmful. It is very variable in colour.

The Greenhouse Slug (*Amalia gagates*, Draparnand) and the Bulb-Eating Slug (*A. sowerbyi*, Férussac) are subterranean in their habits, feeding above ground by night and

below ground by day. The latter, like the earthworm, pulls down leaves into the ground and feeds on them during the day. They also damage the underground parts of plants.

THE BLACK STRIPED SLUG (*Limax maximus*, L.) attains a length of four to six inches. Although not normally a pest it has been known to attack seedling plants, strawberries and wheat.

THE HOUSEHOLD SLUG (*L. flavus*, L.) is frequently to be found about cellars and sculleries. It may become a nuisance in the dairy owing to its fondness for cream.

THE GREY FIELD SLUG (*Agriolimax agrestis*, L.) is by far the most generally harmful species both in fields and gardens. It is variable in colour and about one and a half inches in length when extended. The slime is milky white in colour. This slug often does a great deal of damage to seedling wheat, especially after a clover ley. The species is very prolific, as many as 500 eggs may be laid by one individual during a single season.

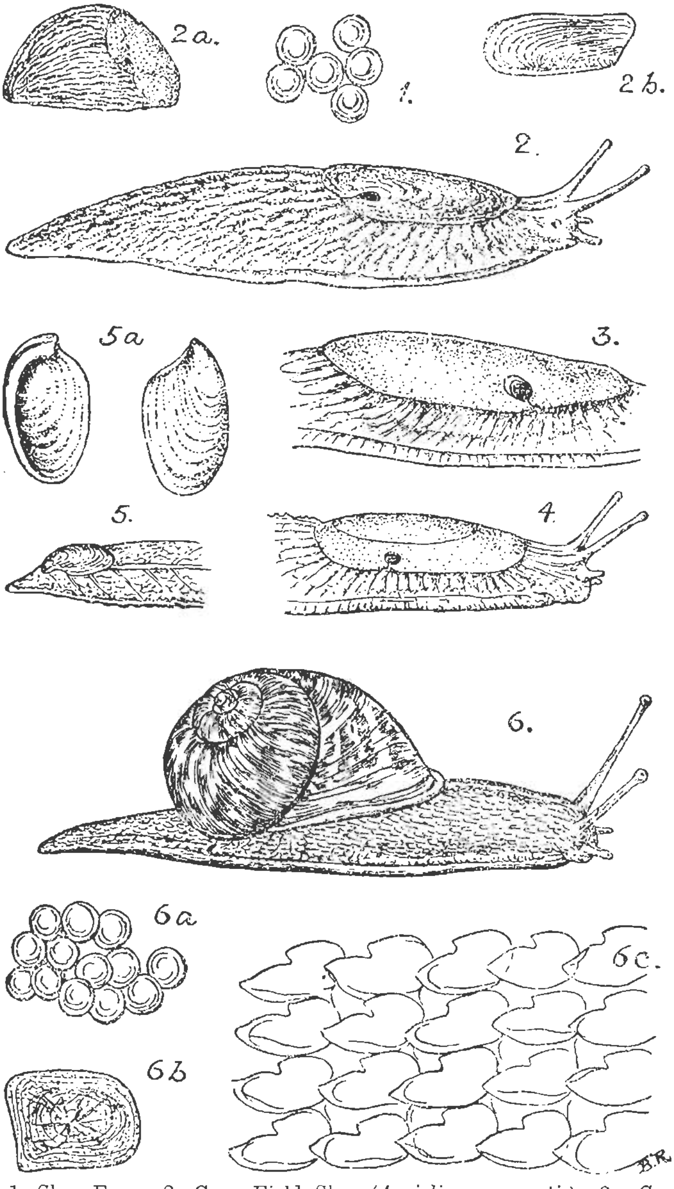
Slugs of the genus *Testacella* can be distinguished by having a small external shell situated near the hind end of the animal. They are subterranean in habits and being carnivorous and predaceous on earthworms, other slugs and wireworms, they should on that account be spared from destruction.

The Garden Slug and the Grey Field Slug are the two kinds to which most of the damage by slugs to cultivated plants may be attributed.

Snails.

THE LARGE GARDEN SNAIL (*Helix aspersa*, Müll) is one of the most widely distributed species and is very common in gardens. It is the largest garden species, being easily distinguished by its grey-brown shell with paler zigzag markings. Eggs are laid in small batches in the earth, about 60 to 70 in each batch. Snails' eggs are white, shining, globular bodies and hatch in about 15 days. The young snails have very thin, transparent shells and grow rapidly. At the approach of cold weather they come together in colonies amongst rubbish and in ferneries, amongst the exposed roots of trees, and in hedge bottoms. They may then often be found in large masses united by the so-called épiphragms (*see* Fig. 2), which they form to close the mouth of the shell.

THE WOOD SNAILS (*H. nemoralis*, L., *and H. hortensis*, Müll) often attack clover and sainfoin and upland pastures. They are among the first to appear in the spring. The shell is very variable in colour, being white, grey, pale yellow, pink and brown, with one to five spiral brown bands and a black edge round the mouth.



1. Slug Eggs; 2. Grey Field Slug (*Agriolimax agrestis*); 2a. Grey Field Slug at rest; 2b. Shell of Slug (*Limax*); 3. Shield showing respiratory pore of an *Arion;* 4. Shield showing respiratory pore of *Milax;* 5. Tail end of a *Testacella* showing shell; 5a. Shells of *Testacella;* 6. Garden Snail (*Helix aspersa*); 6a. Eggs; 6b. Epiphragm; 6c. Part of radula (highly magnified).

The Strawberry Snail (*H. rufescens*, Pennant) is a small snail, seldom more than half an inch long. It is essentially a garden pest and is particularly troublesome in strawberry beds and amongst violets, iris and other garden plants. The shell is much flatter than in the common large snails and is dirty-grey, reddish-brown or brown in colour. It feeds at night and is seen during the day only after rain. The eggs are laid between August and November and hatch in from 20 to 25 days. Each snail may lay as many as 60 eggs, either in or on the ground.

The Small Banded Snail (*H. virgata*, Da Costa) is one of the worst culprits in fields and gardens near the sea. It is also found further inland and especially along chalk downs. The shell is conical and creamy white, with a single purplish-brown band above and others below. Snails of this species come out in great numbers during damp weather and swarm over herbs and bushes, and attack wheat, mustard and field crops generally.

Several other kinds occur in garden and field and do damage to plants.

Control.

(*a*) *Natural Enemies.*—Insectivorous birds should be encouraged or protected. The thrush is especially useful in destroying the large garden snail as well as slugs. Frogs and toads devour slugs and small snails. Fowls, and particularly ducks, are useful, the former more especially for snails, the latter for slugs. Of course, there are many limitations to the use of these controls, though ducklings in the early stages of growth do little damage in a garden.

(*b*) *Sanitary Measures.*—1. Tidiness should be aimed at, especially in rockeries, hedge bottoms and around compost heaps. The latter should be periodically turned with lime.

2. Dry stone walls should be pointed and other hiding places done away with.

3. Where slugs are abundant in highly manured land, the use of stable manure should be discontinued, artificials being used for a time instead. The application of lime is valuable in correcting an acid condition of the soil, which is often associated with an abundance of slugs.

(*c*) *Irritant and Repellant Substances* may be used to protect young plants. Lime and soot, or powdered coke may be sprinkled along the rows of seedlings, but all quickly lose their effectiveness, especially in wet weather, and need to be renewed at intervals. Lime used as a destructive agent, in contra-distinction to its use as a barrier, is of little avail when spread upon the ground in the daytime, though it can be very

effective when thickly dusted upon the ground on a damp night when slugs are exposed. When irritated, however, slugs are able to cast off the offending substance with their slime, and for thorough effectiveness a second dressing may be needed. In gardens as wide an area as possible should be dressed at one time to have a definite effect on the slug population of the place, as after the first shower individuals from undressed areas quickly spread to those areas that have been treated.

In America, copper sulphate (Bluestone) has been tried and found to be rapidly fatal whether powdered or in solution. It cannot, however, be used among green plants or it will scorch them. It was also found that Bordeaux mixture (either in liquid form or the powder sold as " Dry Bordeaux ") could be used as a protective dressing against snails and those slugs which feed above ground. It is both poisonous and repellant.

For protecting valuable pot plants under glass, cotton-wool, which is not easily crossed by slugs, may be tied round the pot. To make it more effective the cotton wool might be dusted with the " Dry Bordeaux."

(*d*) *Trapping.*—Boiled potato, orange skins, chopped clover leaves, bran or lettuce may be used as a bait, being placed under boards and visited at intervals to collect the pest.

Collecting by hand at dusk or after a shower of rain is also useful, more especially for the large garden snail. Perhaps the speediest method of disposing of the slugs and snails so captured is to drop them into a vessel containing strong salt and water.

(*e* 1) *Experimental Dressings.*—Experiments have been in progress to test the effect of aluminium sulphate and lime in water against slugs. While efficient under suitable circumstances, the mixture has a limited application confined to small scale operations. Further information will be sent to those who desire to make a trial.

(*e* 2) For those who would care to try for themselves a method* which has given promising results in initial trials under purely experimental conditions, reference should be made to the spreading of a mixture of copper sulphate and kainit, in the proportion of 5 lb. copper sulphate to 1 cwt. ordinary commercial kainit, the mixture being applied at the rate of 3 cwt. per acre at a time when slugs are on the surface of the ground, a condition of success previously mentioned as necessary in the spreading of lime.

In connection with this method, it is not only the killing power of the mixture upon slugs that needs consideration but

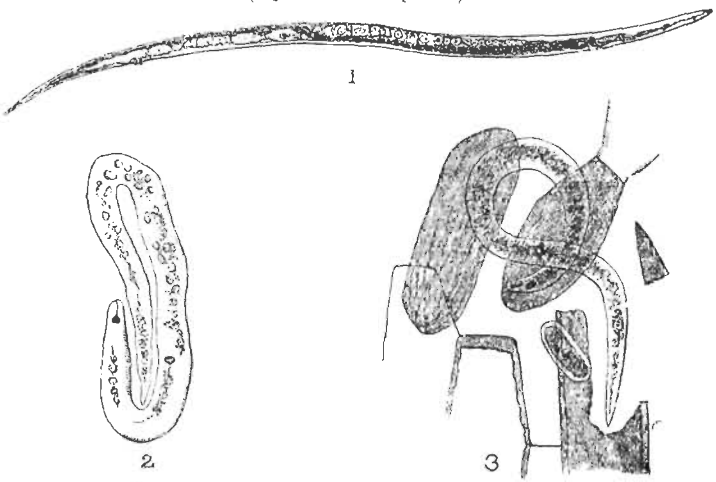
* Anderson, A. W., Dept. of Agric., University of Leeds, *Notes on Experiments on the Destruction of Slugs on a Field Scale.* The N. & W.Y.N.F.U. Record, July, 1925.

its effect on the plants upon which it may fall. *In no instance* should the measure be employed on a large scale without a preliminary test being made on a small area to test whether burning of foliage takes place. Trials have not yet been sufficiently extensive to speak with certainty of its safety in this connection.

(*f*) *Poison Bait.*—Poisoned baits have been used for the destruction of slugs and snails, but the method is not generally applicable and no detailed instructions need therefore be given.

THE STEM EELWORM

(*Tylenchus dipsaci*).



1. Eelworm. 2. Young form just emerged from egg.*
3. Eelworm and egg in plant tissues.
(1 much magnified, 2 and 3 more highly magnified.)

The Stem Eelworm (*Tylenchus dipsaci*, Kühn = *devastatrix*, Kühn) is a common pest throughout the country, and year by year is responsible for serious losses both to crops grown on the farm and in the market garden, while it is also very destructive to certain flowers and ornamental plants. It must be noted, however, that the term "eelworm" is often applied to forms of crop failure which have no connection whatever with eelworms, and there is a tendency to attribute to these pests all damage of a mysterious nature. Eelworms are very minute animals, invisible to the naked eye, making it difficult for a grower to diagnose an attack with certainty.

* These figures are reproduced from *L'Anguillule de la Tige*, by courteous permission of Dr. Ritzema Bos.

The difficulty is increased by the fact that all kinds of eelworm are not harmful and also that true eelworm attack is often found in combination with the attacks of other pests. It is therefore suggested that in all cases in which loss due to eelworm is suspected, specimens of the affected plants should be submitted to an expert for examination.

Plants Attacked and Nature of Injury. — Stem Eelworms—or rather animals indistinguishable in form from the Stem Eelworm—have now been found attacking a very large number of different plants. There is still, however, some uncertainty as to the extent to which eelworms living on one crop are capable of adapting themselves to a different crop from that on which they have been living. For instance, it seems possible that eelworms which for many generations have lived exclusively on clover may find considerable difficulty in transferring their attentions to such a distinct plant as the oat, and the view is held by certain authorities that although the Stem Eelworm is a single species, yet it develops races more or less attached to certain combinations of food-plants. From the practical point of view it is most important that more light should be thrown on this subject, for the chief method of controlling eelworms is to arrange the rotation so that susceptible crops are not taken too frequently, and it is therefore necessary to know with certainty which crops each race of eelworms is capable of attacking.

Clover.—The most familiar disease associated with the Stem Eelworm is one of the two forms of " clover sickness." The attack is usually noticed in the autumn when patches in the new lea begin to " go off." The respective plants in these patches are seen to be stunted, the shoots becoming swollen, but not growing in length, while the leaves are usually lighter in colour than those of normal plants. Gradually, and especially during a wet winter, the affected patches spread, and as the diseased plants usually die, become bare of clover. This form of clover sickness is quite different from the form caused by the fungus *Sclerotinia* (*see* Leaflet No. 271) and is to be distinguished by the swelling and thickening of the shoots combined with the stunted growth which are characteristic of the eelworm.

Oats.—In this country the oat is the chief cereal which suffers from the Stem Eelworm (*see* Fig. 4)—though Frit fly attack is so often ascribed to eelworms, that it is difficult to say how serious the losses usually are. The chief sign of attack is that the base of the plant swells and becomes " tulip rooted "; the leaves also are often twisted and pale in colour, while the whole plant is generally stunted and fails to produce a crop. Plants attacked by Frit fly are also stunted, but the

FIG. 4.—Attacked Oat Plant.

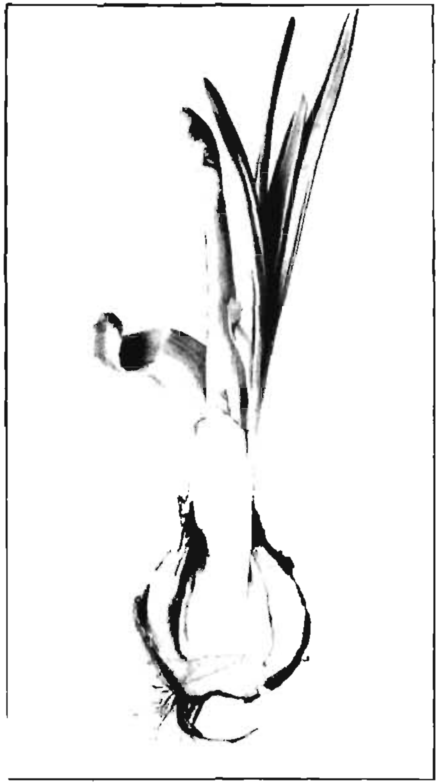
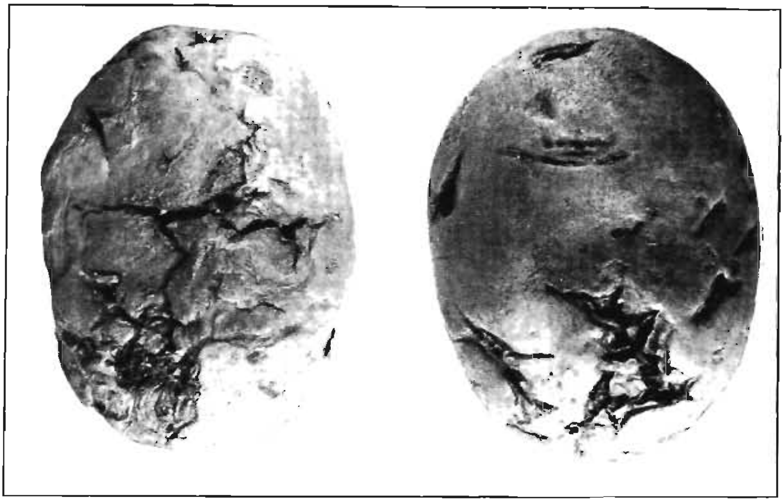


FIG. 5.—Attacked Narcissus Bulb.



facts that the central shoots have been definitely eaten away, and that small white grubs are present, will usually distinguish them from plants attacked by eelworms. Not seldom both eelworm and Frit fly attacks occur in the same crop. In addition to oats, wheat and rye are also attacked, but more especially abroad, where great damage is sometimes caused to the rye.

Onions.—Onions may be seriously damaged by the Stem Eelworm. The young plant develops swollen and twisted leaves, and the upper part of the stem becomes unduly thickened, the tissues being soft and flabby. This condition is sometimes known as " bloaty." Attacked plants rot and die, never producing a crop unless the infection has taken place very late, when decay takes place in the store.

Potatoes.—The Stem Eelworm has recently been found to attack potatoes in this country, particularly in S. Lincolnshire.* The tubers alone exhibit symptoms of the disease, the haulm and foliage being apparently unaffected.

The tubers bear at first a number of small discoloured patches on the surface, and on cutting open one so affected, brownish patches extending a short distance into the substance of the potato will be noticed: large numbers of eelworms can be found in these patches. Later the patches increase in size and give rise to large cracks on the surface of the tuber, which eventually entirely rots. In the clamps rotting takes place with great rapidity. In some cases the early symptoms of the disease somewhat resemble those of " Blight," and not infrequently the two diseases are found concurrently. (*See* Figs. 6 and 7.)

Daffodils.—The serious disease formerly attributed to the fungus *Fusarium* has now been shown to be due largely to the Stem Eelworm. For a full account of the disease reference should be made to papers by Welsford† and Ramsbotham.‡

Some of the signs of attack are as follows:—Attacked bulbs start into growth abnormally early. The leaves are crinkled and often show pale stripes. A section through an infested bulb shows that certain of the bulb scales have turned dark brown in colour, having been killed by the eelworms. Gradually the attack spreads from one scale to the next, and the whole bulb dies and rots.

Hyacinths suffer from a similar form of attack.

Life-History.—The full-grown eelworm (*Tylenchus dipsaci*) is about one twenty-fifth of an inch long. Its length varies somewhat in different plants. In appearance it

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* Goodey, *Journal of Helminthology*, Vol. 1.

† *Annals of Applied Biology*, Vol. IV, p. 36.

‡ *Gardener's Chronicle*, 19 May, 1917, p. 207; 26 May, 1917, p. 217; and 2 June, 1917, p. 226.

resembles a tiny eel, with both ends pointed, the hind end specially so. It has a sharp spear-shaped point within the gullet (seen under a high magnification). The eggs are oval, and sometimes oblong in shape, as shown in the figure, and are found in the tissues of the host-plants, together with partly grown and fully developed eelworms. When the young worms come from the eggs, they are about one-seventh of the size of the adult eelworm, and resemble them in outward appearance, though their internal parts differ somewhat. The young form undergoes several changes or moults before it becomes a perfect eelworm. When the tissues of the host-plant decay and dry up, the eelworms and the young forms either fall to the ground and enter it, or the eggs and young worms remain in the decaying and dead parts, and become dried up with them. Eggs containing the embryo worm can be kept dry for six months without losing their power of hatching, and young worms have the power of resuming animation and active life after they have remained in a perfectly dry condition, in dead tissues or in dry soil, for a considerable period. It is apparent that this faculty enormously increases the chances of the distribution and spread of the eelworm, which may be carried in various ways into fields and gardens in this dried-up state.

In America it has recently been discovered* that the eelworm is capable of being distributed in the seeds of certain plants. The germinating power of the seed is not affected in many cases, but as soon as germination has taken place, the attack on the seedling is commenced.

Methods of Control.—(1) Eelworms are exceedingly difficult to control, and prevention should be the object rather than cure. On farms which suffer from eelworm sickness of clover a long interval should be allowed between successive clover crops. In order to overcome the difficulty as regards rotation which this entails, leguminous crops less liable to attack should be taken. Amos,† by growing the crops on badly infested soil, came to the conclusion that Sainfoin, Peas, Beans and Vetches (except Kidney Vetch) do not suffer from eelworm, while White Clover and Trefoil are rarely attacked and Crimson Clover suffers slightly—the case of Lucerne being regarded as doubtful. Certain of these plants, *e.g.*, Beans, have been recorded by other workers as being injured, but it is probable that they may be relatively immune from the race of eelworm usually found on Red and White Clovers, and there is therefore a choice of crops to replace the latter in the rotation.

* Godfrey, *Journal of Agricultural Research*, Vol. XXVIII, No. 5.
† *Journal of the Farmers' Club*, May, 1916, p. 61.

(2) In the case of both Clover and Oats vigorous growth tends to overcome a slight attack and this may be induced by applications of such manures as ammonium sulphate and nitrate of soda. Potassic manures—such as potassium sulphate—are said to have given good results both in the case of oats and clover, and it appears that they may have some definite action on the eelworm.

(3) The discovery of the distribution of eelworms in certain seeds should not be forgotten—although its application to farm seeds has not yet been demonstrated.

(4) Little can be done when onions are attacked, and it is necessary to avoid growing onions for several years on land which has become infested.

(5) It has been found that by soaking daffodil bulbs for three hours in water heated to a temperature of 110° Fahr. the eelworms are destroyed; bulbs are in the best condition for treatment when ripe in July, August, September. Special apparatus which automatically retains the water at the right temperature can now be purchased.

(6) Affected daffodils should be removed as soon as it is apparent that they are diseased. When a bulb in a row fails to appear in the spring it should be dug up before it has time to decay.

(7) Refuse from attacked crops should be burnt or otherwise destroyed before it has time to rot. In no circumstances should such refuse be thrown on the manure or waste heap, as this would in all probability lead to a fresh attack.

SURFACE CATERPILLARS OR CUTWORMS.

Cutworms or Surface Caterpillars are terms applied to the larvæ of a number of different species of moth which frequently cause a great deal of damage to cultivated plants, both in Britain and in almost every other country in the world.

In Britain the most harmful kinds are the caterpillars of the Turnip Moth (*Agrotis segetum*, Schiff). the Heart-and-Dart Moth (*Agrotis exclamationis*, L.) and the Yellow Underwing Moth (*Agrotis pronuba*, L.). but there are many others, mostly belonging to the same family, which might be included with equal justice. In this leaflet it is only possible to give a general description of the more characteristic habits of the group.

Nature of Injury.—The damage caused by Cutworms varies considerably and can best be described in connection with the habits of the pests. Cutworms, as a rule, spend the day in the surface layers of the soil or hidden under

leaves, thick grass or stones. At night they come out and feed, sometimes on the leaves of plants, but more often on their stems, both above and below ground, and are specially fond of the thick, fleshy parts of such crops as mangolds, turnips and potatoes. They also bite through the stems of plants at, or just below, the ground level, cutting them off one after another, and from this habit they have been given the name " Cutworms." Since the caterpillars are often of the same colour as the soil on, or in which they live, they are not easily seen, and damage may continue for some time before the nature of the pest is realised. An examination of the crop after dark, when the caterpillars are feeding, is perhaps the simplest way of discovering their presence.

It would be difficult to give a list of all the crops attacked, but the following are some of the most important:—

Wheat and other autumn-sown cereals at times suffer considerably during the winter, the caterpillars feeding whenever the weather is mild, eating away the stems and leaves.

Potatoes are attacked in the field, the tubers being gnawed and hollowed out. *Mangolds and turnips* are also eaten out in the same way, small plants being bitten right through, while large roots are hollowed out, leaves as well as roots being sometimes attacked. (Fig. 6.)

Many vegetable crops are damaged and the pests are also harmful to young forest trees in the nursery, biting through or barking the stems below ground.

Damage by Cutworms may occur at most times of the year, except in late spring and the first half of summer, when the insects are present either as chrysalides or moths and are incapable of causing any injury.

Description and Life-History.—The general appearance of the moths of the three species of Cutworms mentioned is shown in the figures. The Turnip Moth (Figs. 1 and 2) has the front pair of wings greyish brown with darker markings —in some individuals quite black—with the hind pair of wings pearly white. The Heart-and-Dart Moth (Fig. 4) has brown fore wings with brown and black markings, and the hind wings in the male are pearly white; in the female brownish. The Large Yellow Underwing (Fig. 3) has the fore wings brown, sometimes extensively mottled with brownish black, and the hind wings orange yellow with a black border. The caterpillars—the " Cutworms "—of the Turnip Moth (Fig. 5) and of the Heart-and-Dart Moth are much alike.* They are dirty grey in colour, sometimes tinged with chestnut brown, and have rows of blackish dots

* In the Heart-and-Dart caterpillar the spiracles are quite black and are larger than the spots before and behind. In the Turnip Moth caterpillar the spiracles are dusky and are smaller than the adjacent spots.

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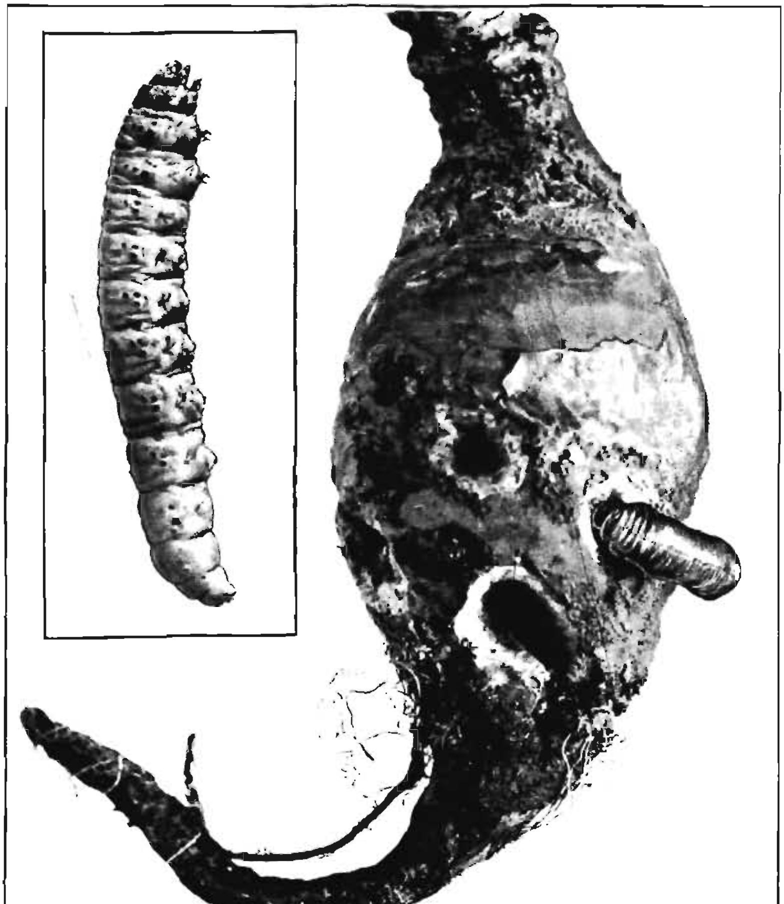

FIG. 5.—Caterpillar or "cutworm" of Turnip Moth.
FIG. 6.—Damaged swede with "cutworm" feeding.

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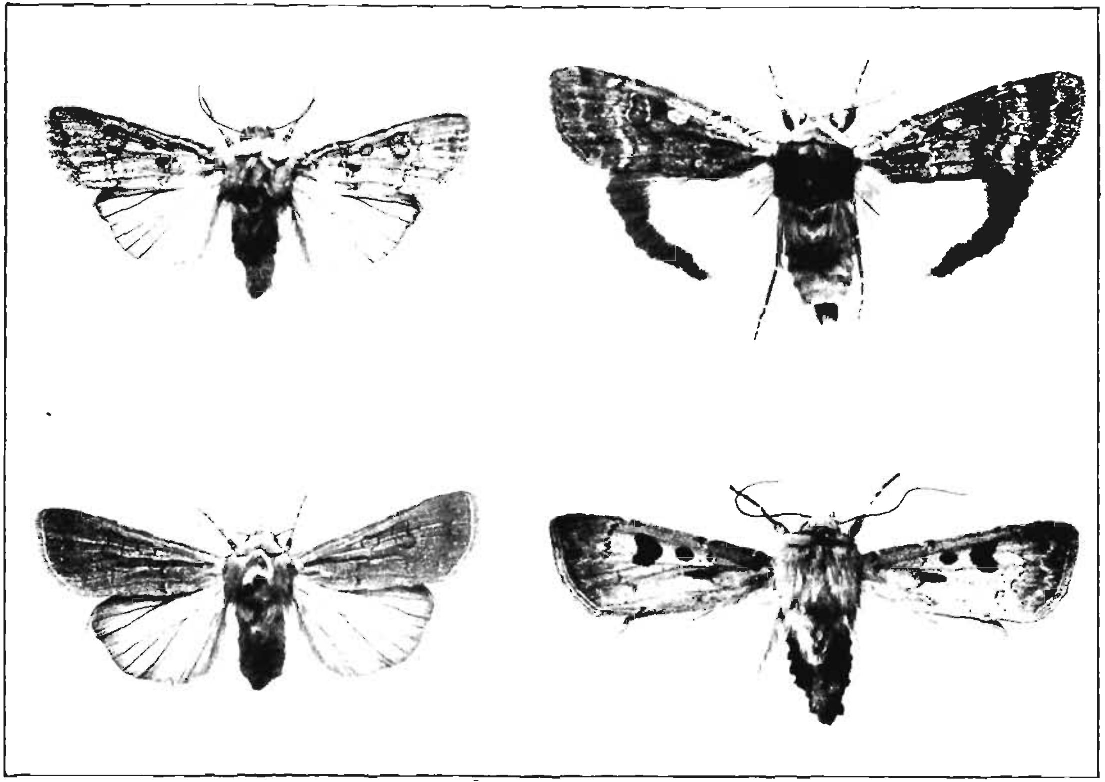

FIG. 1. Turnip Moth (*Agrotis segetum*). Male.
FIG. 2. Female.
FIG. 3. Yellow-Underwing Moth (*Agrotis pronuba*).
FIG. 4. Heart-and-Dart Moth (*Agrotis exclamationis*).

along their sides with faint traces of stripes passing down the body from head to tail.

Apart from other Cutworms these caterpillars are not likely to be confused with any other pest except perhaps with Leather Jackets (Daddy Longlegs grub)* from which they may be distinguished by the fact that they possess legs whereas Leather Jackets do not.

The caterpillar of the Large Yellow Underwing Moth varies greatly, the ground colour ranging from reddish brown to grey or even greenish. There is a light coloured stripe down each side with more or less conspicuous black marks just above it. The under part of the caterpillar is always darker than the upper parts. No general description, however, can give much idea of this caterpillar.

The life-histories of all these insects are more or less the same. The adult moths appear from the beginning of June until the end of July, the Turnip Moth being the earliest species, and the Yellow Underwing the latest, though all may be found together. Eggs are laid on the leaves or stems of many common weeds and cultivated plants, and produce caterpillars 10 to 14 days afterwards. In a warm season a certain number of these caterpillars feed rapidly, and change into chrysalides at the end of July or in August, producing another brood of moths in August or September. The remainder of the caterpillars, usually the majority, feed more slowly and continue feeding whenever the weather is suitable throughout the autumn and winter. The September moths also lay eggs hatching into caterpillars which feed through the autumn and winter, reinforcing the army of caterpillars derived from the first brood. From February to April the caterpillars are full-fed, and turn to brown chrysalides in the soil. They remain in this stage until the beginning of June, when moths are produced, and the life-cycle begins again.

Methods of Control.—(1) Cutworms are specially likely to be troublesome on foul, weedy land. Fallows, for instance, after being cleaned from such weeds as couch may still produce a crop of annual weeds which, if not destroyed, are attractive to the moths when egg-laying. Potatoes again which are not free from weeds are likely to be attacked.

(2) Grass land required for wheat sowing the following autumn should be broken as early as possible—preferably by the beginning of July. This will avoid attacks both by Cutworms and Leather Jackets and may well compensate for the loss of a small crop of hay.

(3) When crops of potatoes or mangolds have been badly attacked it is risky to sow winter wheat unless the pests have first been destroyed.

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* *See* Leaflet No. 11, included in this volume.

(4) Undoubtedly the best method of dealing with cut-worm infested land is to run poultry upon it, and wherever this is possible it should have precedence over all other treatments. Reports show that the birds benefit by a cut-worm diet and that they will greedily eat all the caterpillars they can find.

(5) When an attack is in progress hoeing or harrowing is of some value, disturbing the Cutworms, injuring some and exposing the others to the attacks of birds.

(6) When young root crops are being attacked above ground, the plants may be sprayed with lead arsenate (1 lb. lead arsenate paste to 25 gallons water). Provided the plants are *small* so that the greater part of the root has yet to be made, there will be no risk of poisoning stock when the roots are finally eaten. *Lead arsenate is poisonous to man and domestic animals and must be used with due care.*

(7) In market gardens and allotments hand-picking is often the most simple method of dealing with the pests, which can be scraped out of the soil near the plants last attacked by means of a blunt knife or pointed stick. They may also be collected at night when they are feeding or crawling about on the surface of the soil.

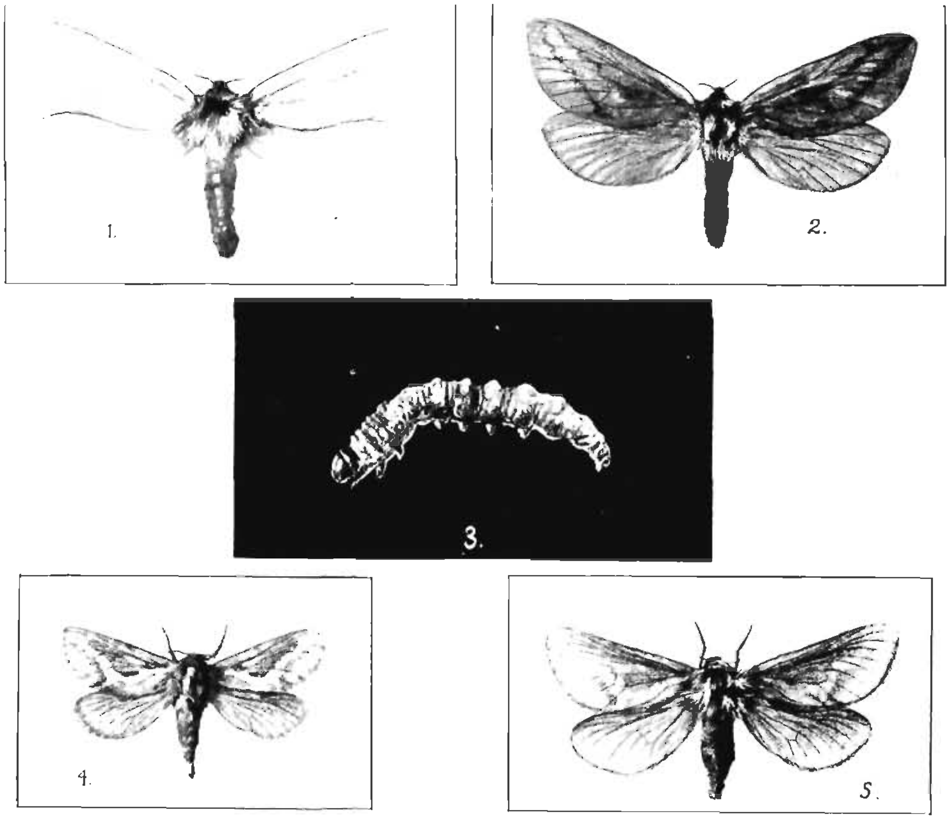
(8) Cabbages, &c., which are planted out from a seed bed may be protected by folding a strip of paper from 2 to 3 in. wide round the stems so that rather more than half this collar is below the ground. The paper will unfold or decay as the stems increase in size.

(9) In Canada and the United States where the loss due to Cutworms is always great, the standard treatment is to poison the caterpillars by means of moist bran mixed with Paris green. A similar treatment has given good results in Britain, but in view of the Protection of Animals Act, 1911, it appears that the poisoned bran may only be used where "all reasonable precautions" are taken "to prevent access thereto of dogs, cats, fowls or other domestic animals." Both for this and other reasons the circumstances, under which the treatment is advisable, are rather limited, and in consequence instructions for preparing the bait are not given in this leaflet.

SWIFT MOTHS.

Of the five species of swift moths found in Great Britain, the caterpillars of two, the Ghost Swift Moth and the Small Garden Swift Moth, are capable of effecting considerable damage.

Unlike the majority of moths the caterpillars of which feed upon the foliage of plants and trees, the caterpillars of



1. Ghost Swift Moth (*Hepialus humuli*). Male. 2. Female. 3. Larva.
4. Small Garden Swift Moth (*H. lupulinus*). Male. 5. Female.

swift moths spend this period of the life cycle beneath the surface of the ground, devouring the roots of plants. The list of plants so attacked by both species is very big, including large numbers of herbaceous subjects as well as those of a woody nature such as shrubs and trees. Damage is frequently done to market garden crops, nursery stock and to grass; probably the damage most often reported as attributable to the Ghost Swift has been occasioned to hops, while strawberries frequently suffer from the depredations of the Small Garden Swift.

Notwithstanding their size these moths belong to the more primitive group amongst moths and are more closely allied to those whose caterpillars mine leaves and tunnel into shoots or feed amongst the roots of plants, than to the more familiar, because more obvious species, whose caterpillars, chiefly coloured and often hairy, feed externally upon foliage in a more or less exposed manner.

Both the caterpillar of the Ghost Swift Moth and that of the Small Garden Swift Moth are white in colour, as are the larvæ of all five species of swift moth; indeed, the majority of the larvæ of insects which spend this period of their lives in darkness are white, or nearly so, though exceptions occur.

The caterpillars of the Ghost Swift Moth and the Small Garden Swift Moth are closely similar in appearance, but that of the former, when full grown, is much larger, since the size of the moth is also greater. Except in the case of full-grown larvæ size is of little use in distinguishing the larvæ of the two species, which are indeed very much alike.

Description and Life History.

The Ghost Swift Moth (*Hepialus humuli*, L.).—*Moth.*—*Male* (Fig. 1).—A fairly large moth 1½-2½ in. across the wings when spread. All four wings silvery white with a pink fringe, though the hind pair may be greyish. *Female* (Fig. 2).—Front pair of wings yellow buff with oblique wavey pinkish markings, hind wings greyish tinged with pink at the apex. Swift Moths have the antennæ very small and thin, much more so than is the case with other moths.

Pupa.—The pupa or chrysalis is brown in colour and very active. By means of small spines it is able to wriggle to the surface of the soil before the moth emerges.

Larva (Fig. 3).—Whitish in colour, head red-brown, with a red-brown plate on the joint behind it. The spiracles or breathing pores along each side of the body are black and the surface of the body shows black dots from which emanate black hairs. This larva has six true legs in front and five

pairs of pro-legs or claspers behind and is characterised by the ability of wriggling backwards as well as forwards.

Egg.—Small and round, greenish when first laid, but subsequently becoming black.

Life-History and Habits.—In one respect the habits of this insect are peculiar from the circumstance that it is the female which seeks out the male, a reversal of the usual procedure. The male hovers swaying to and fro over the same spot, its silvery whiteness being conspicuous in the dusk of June and July evenings. The searching female knocks up against this swaying male, causing him to fall to the ground where pairing takes place; the female subsequently flies about discharging her eggs as she goes. The caterpillars hatching from these eggs feed at the roots of the plants near to which the eggs drop, until the following April or May when pupation takes place. There are some reasons for supposing that these larvæ at times live through the succeeding summer and do not pupate until the year after. Before the emergence of the moth, the pupa wriggles to the surface and the empty pupa case may be seen projecting from the soil.

The Small Garden Swift Moth (*Hepialus lupulinus*, L.)—*Moth.*—*Male* (Fig. 4)—Considerably smaller than the Ghost Swift Moth, averaging about 1 inch in wing spread. The front pair of wings are yellowish brown with whitish markings, the most prominent of which is an oblique line, composed of more or less square-shaped dots, running downwards and inwards from the tip. Hind wings greyish brown. *Female* (Fig. 5).—Often similar on the upper surface but not infrequently the markings are absent or nearly so; sometimes a more extreme aberration takes the form of a plain brownish cream tint on all four wings. Both sexes are, however, very variable in general coloration.

Larva and Pupa.—The larva and pupa resemble those of the Ghost Swift Moth but are proportionately smaller.

Life-History and Habits.—Except that the peculiar habit of pairing is not followed by this species, the life-history is similar in general outline to that of the Ghost Swift Moth. The males of the Small Garden Swift Moth are frequently very numerous, flitting over grass and herbage at dusk in early summer. The list of plants the roots, bulbs and rhizomes of which serve as food for the caterpillars, is very long.

Methods of Control.

1. *Digging and Replanting.*—Swift moth larvæ are usually found in places where the soil and plants growing in it have seldom been disturbed, and this also applies to the garden

border and waste land. In reclaiming the latter, damage may be expected during the first few months after digging, but, if the soil is properly turned, there is likely to be little subsequent trouble. In the case of borders, fairly frequent replanting should be the rule.

2. *Perennial Crops.*—Strawberries, hops, &c., should not be planted in land infested by the larvæ of swift moths or other soil pests. This advice may seem so obvious as to be not worth giving, but it is surprising how often it is neglected. The devotion of a season or even more to clearing the pests from the land (during which time *annual* crops may be sown) is well worth any temporary loss occasioned.

3. *Insecticides.*—Swift moth larvæ are reported as being distinctly susceptible to naphthalene, which is worth testing at the rate of 1 oz. to the square yard, working the insecticide well into the soil. Under certain conditions and in soils which are not too heavy, injections of carbon bisulphide should prove useful. The chemical should be used with an injector. The amount to use, the distance apart, and the depth of the injections, are matters which would vary with the nature of the soil and the kind of plants attacked, *i.e.*, shallow or deep rooting. In a friable soil under average conditions, $\frac{1}{8}$ oz. of carbon-bisulphide injected at intervals of 1 foot to a depth of 3 inches should prove effective. Further suggestions to meet particular cases will be made upon application to the Ministry. In order to avoid an explosion no light of any sort should be allowed in the neighbourhood when using carbon-bisulphide. The operator should on no account smoke.

4. *Natural Enemies.*—Swift moth caterpillars are preyed upon by birds and moles. According to Stenton they are also subject to parasitization by an Ichneumon fly (*Alomyia debellator*, Fab.), which pursues them in their tunnels amongst the roots of the food plants. Colonies are also decimated occasionally by two species of parasitic fungus, viz., *Cordiceps militaris* and *C. entomorrhiza.* These fungi have not, however, proved amenable to manipulation in such a way as to provide an instrument for use against the pests.

5. *Plants for Export.* — Those who export plants to foreign countries should note that often Pæony tubers and sometimes Iris rhizomes are tunnelled by swift moth larvæ, which remain in the plants and cause their subsequent rejection by the quarantine authorities of other lands.

THE TURNIP GALL WEEVIL

(*Ceuthorrhynchus pleurostigma*, Marsh).

The grubs of the Turnip Gall Weevil are pests of both turnip and cabbage crops, but considerable difference of opinion prevails as to the actual amount of damage occasioned by them. This diversity is probably due to the wide range of soils upon which plants of the cabbage tribe are grown, for a soil in good heart eminently suitable for the cultivation of cabbage enables the plants to attain to a vigour that renders an attack negligible in effect. On the other hand, a soil not really suitable for cabbage will naturally carry a worse crop if the plants are affected than if they are clean, as in poor soil the plant's whole energy is required to make the most of the unsatisfactory conditions, without taking the pest into account. The Turnip Gall Weevil is widely distributed throughout the United Kingdom, and records of its attacks have been received from most English counties. It is also well known on the Continent, and is said to be destructive in France, Russia and Germany.

Owing to the fact that injury caused by the weevil somewhat resembles that due to the more serious finger-and-toe, the presence of the former is not always realised. In the case of finger-and-toe, a fungus (*Plasmodiophora brassicae*) is responsible for the malformation of the root, while in the case of an attack by the gall weevil the growths are definite galls formed by the larvæ of this insect. Care should be taken to distinguish between the two diseases, as the methods of control are different. The general appearance of roots attacked by the gall weevil is shown by Figures 2 and 3, and the characteristic features of the disease are dealt with in the following section.

Plants Attacked and Nature of Injury.—The various forms of turnip, mustard, charlock, rape, cabbage, Brussels sprouts, savoy, and kohl-rabi are attacked, but complaints most often refer to the turnip and cabbage. In the case of root crops the damage lies in the loss of crop, which is most marked when the plants are attacked at an early stage. If cabbage plants are badly attacked they may be stunted and make little " head."

The growths produced by the weevil (Figs. 2 and 3) may always be distinguished by the fact that they are hollow and frequently contain a grub (larva). The galls are always more or less rounded and are never elongated, finger-like growths such as are formed in an attack by finger-and-toe. Roots injured by the beetle show little tendency to rot, even after the larvæ have left the galls, while the fungus usually causes extensive decay.

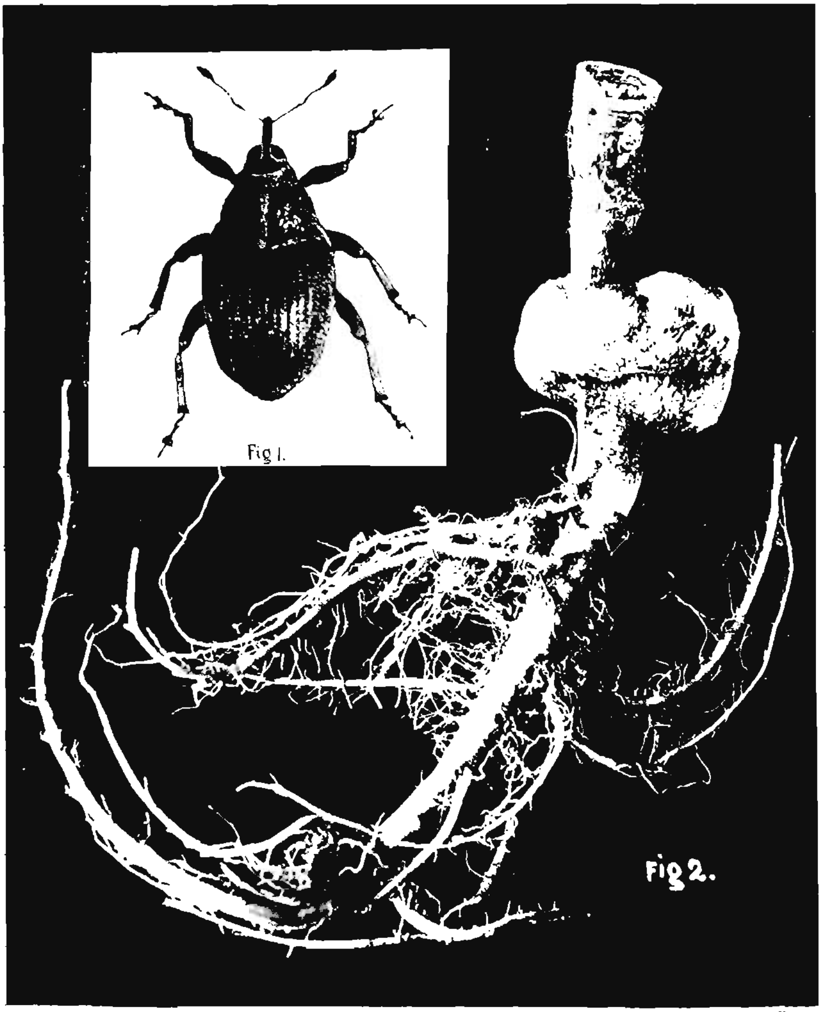


FIG. 1. Turnip Gall Weevil (*Ceuthorrhynchus pleurostigma*, Marsh).
FIG. 2. Cabbage root showing galls.

FIG. 3.—Swede turnip, showing galls.

FIG. 4. Section of a gall showing larvæ of Turnip Gall Weevil.

Description of Insect.—The adult insect (Fig. 1) is a small beetle about ⅛ inch in length with a long proboscis. In colour it appears to be black above and greyish on the underside, but if it be examined through a lens it will be seen that the upper surface is sparsely dotted with grey and white. Several other species of weevil are harmful to turnips, cabbage, &c., the larva of one (*C. assimilis*, Pk.) living in the seed pods, of another (*C. quadridens*, Pz.) in the stems of the flowering plants, while a third (*C. contractus*, Marsh.) as an adult attacks the seed leaves (cotyledons) of the young plant. The differences between these various species are minute, and from the growers' point of view not worth entering into, since each species may be known by the form of injury it produces.

The larva is a small shining white or yellowish maggot with a brown head. It is legless, and is found inside the galls usually in a curled up or semi-circular position (Fig. 4).

The pupa is white, and lies in the earth in a cell formed of particles of soil glued together by a sticky material secreted by the larva.

Life-History.—The adult beetles emerge in spring and summer, and the females then lay their eggs just beneath the bark of the root of the foodplant. The eggs are laid singly and are inserted in holes made by the proboscis or trunk of the female weevil. Several eggs are frequently laid in one root. On hatching, the young larva feeds on the root, which is stimulated in some way so that it forms a gall such as shown in Figs. 2 and 3. The gall at first is small, but grows gradually until it may attain the size of a small marble; in many cases several galls coalesce to form a single large out-growth in which may be found a number of chambers each tenanted by a larva; a section of such an out-growth is shown in Fig. 4. When full fed the larvæ bite their way out of the galls and enter the earth, where they form the cells described previously, and there pupate.

The length of time spent in the various stages seems to vary within wide limits. According to Isaac the beetle is single brooded and divided into two races, one attacking cultivated plants—the other weeds such as charlock. Others believe that there may be two broods—one which lays its eggs on charlock and seedlings of the cabbage tribe in spring and early summer, and a second in late summer which chiefly selects the young plants of various "winter greens." However this may be, it is clear that both adults and maggots can be found almost throughout the year, and that the majority of the latter leave their galls to pupate in early spring. The subject requires further investigation.

Methods of Control.—(1) Where the turnip crop is attacked the turnips should be consumed as soon as possible so as to destroy the larvæ before they leave the galls.

(2) Isaac found that if cabbage or other stumps be rooted out as early as possible in spring and stacked in large heaps to dry, the maggots are unable to emerge from the dried roots and therefore perish.

(3) The results of planting galled seedlings on poor land are more serious than when they are placed in rich soil. Galled seedlings should be avoided where possible, but if they must be used, the grower need not despair of getting an average crop; the plants, however, must not be starved and everything possible should be done to get a rapid growth immediately after planting out.

THE WHEAT BULB FLY

(*Hylemyia coarctata*, Fall.).

Although it is over forty years since damage to the wheat crop by the Wheat Bulb Fly was first noticed in Britain, the pest has not, until recently, attracted the attention it deserves either on the part of farmers or of entomologists. This neglect has been paid for by losses which in the aggregate must be very large, since the insect is undoubtedly one of the few really serious pests with which the wheat crop in Britain has to contend. Fortunately recent investigations into the habits of the fly have improved the position, and it is now possible to indicate both the conditions under which attacks may be expected and to some extent how they may be avoided, although it is not yet possible to give much assistance when an outbreak is far advanced.

Distribution.—The Wheat Bulb Fly is widely distributed throughout Britain wherever wheat can be grown with success. The Fen districts of the east of England suffer constantly, hardly a year passing without cases of serious damage. In other areas attacks of the fly occur less frequently, but they are liable to take an epidemic form, severe losses being incurred every now and again with little evidence of the pest in the interim. Lack of evidence, however, does not necessarily mean that some losses do not occur, since the injury due to the Wheat Bulb Fly is often ascribed to wireworms, unfavourable weather, &c., and whenever a wheat crop begins to thin out in the spring, especially when following a fallow or root crop, the presence of the fly should be suspected. Abroad the Wheat Bulb Fly is widely distributed in the wheat-growing countries of

Europe, but, as was formerly the case in England, it appears to have been insufficiently studied and little information of value has been obtained from Continental investigation.

Crops Attacked and Nature of Damage.—In England wheat appears to be the only crop which is seriously damaged, though there have been one or two records of injury to winter barley. Rye is said to suffer on the Continent, but up to the present it has not done so in England. Among wild plants it is known that couch-grass (*Agropyrum repens*) can serve as food for the pest.

The injury to wheat is caused by the grub or larva of the fly which feeds during the spring within the young shoot or tiller, devouring the growing point and causing the central leaf first to flag and then to turn yellow and die. In the field the attack in its early stages is not very conspicuous owing to the fact that, although the central leaves of infested shoots turn colour, the outer leaves for some time remain fresh and green, and give a healthy appearance to the field as a whole. The first obvious sign that something is wrong is that the crop appears to be thinning out. Close examination at this stage will show that many plants have already died and perhaps shrivelled up in the drying spring winds, while others show yellow or brown central leaves surrounded by leaves still green. The loss continues and may in bad cases result in the death of over 75 per cent. of the plants in the field; more often from one-third to one-half is spoilt, and this loss may be distributed all over the field or confined to special patches. As has been mentioned, the attack takes place during spring, but the exact time varies both with the season and the district. Usually the first obvious signs of damage may be detected in March; during April the loss of plants continues, while at the beginning of May, or soon after, the injury will have reached its height and no further outbreak will take place during the season.

When a crop under attack is closely examined the presence of Wheat Bulb Fly is fairly evident, but to those unfamiliar with it the injury is often attributed to wireworm. It may, therefore, be mentioned that the characteristic sign of wireworm attack is that not only the central leaf but also one or more of the *outer* leaves of a shoot or tiller turns yellow, since the wireworm, in burrowing into a plant, bites through the base of the outer leaves before reaching the centre. A further indication of a wireworm attack is that four to five consecutive plants in the row are killed, while Wheat Bulb Fly attack is usually more scattered. Finally, suspicions of Wheat Fly can always be confirmed by pulling up a few plants showing shoots with yellow central leaves. If such shoots are carefully pulled to pieces the white

maggot of the Wheat Fly will be found lying at the bottom of the yellow central leaf. This examination is best carried out indoors; in the open the maggot may easily be overlooked. (*See* Fig. 3.)

Description and Life-History.—From the earliest times it has been noted that serious outbreaks are almost always on land which the previous year was either bare fallow, carried a potato crop, or some crop which did not completely cover the ground for a period during the latter half of summer. The reason for this has proved a complete mystery until recently when a study* of the habits of the fly has thrown some light on the matter. As mentioned previously, an examination of an attacked wheat plant in spring will result in the discovery of a white maggot feeding in the heart of a shoot. This maggot when full grown — in April or May—measures nearly ⅜ in. in length. It then leaves the plant and pupates in the soil, the puparium being dark-brown and barrel-shaped. The insect remains in this stage for about a month and the pupa then turns into the adult winged fly, which resembles somewhat the common House Fly in appearance, though in colour it is lighter. (*See* Figs. 1 and 2.) These flies, which appear during the month of June, may be found throughout the months of July, August, and even into September, being most noticeable on the ears of wheat when in flower. It was formerly believed that the female flies laid eggs in June and July on some plant other than wheat and so produced a second brood during the year. It is now known that this belief was wrong. Instead, the flies lay their eggs in July, August or September just below the surface of the soil on land which is bare—or not greatly shaded by crops. Thus fallows or bastard fallows offer the greatest attraction: roots also leave uncovered land, while potatoes, if of an early variety, will be cleared by the end of August, and if late may not meet in the rows during the first part of July, or again may die off early in September from the attacks of blight or an early frost.

The eggs laid in the soil remain unhatched throughout most of the autumn and perhaps early winter, and are uninjured by cultivation or even by being buried to a considerable depth. By early spring the eggs have hatched into little maggots which are dependent on finding near to them plants of wheat, winter barley or couch-grass. If these plants are not available the maggots die, but, if more fortunate, they find the food they require and burrow into the young shoots where they feed in the manner already described. There is thus a considerable element of chance in the life-history of the Wheat Bulb Fly, for the female fly can have no know-

* Petherbridge, *Journal of Agricultural Science*, vol. xi., p. 99. 1921. Gemmill, *Scottish Journal of Agriculture*, vol. vi., p. 192. 1923.

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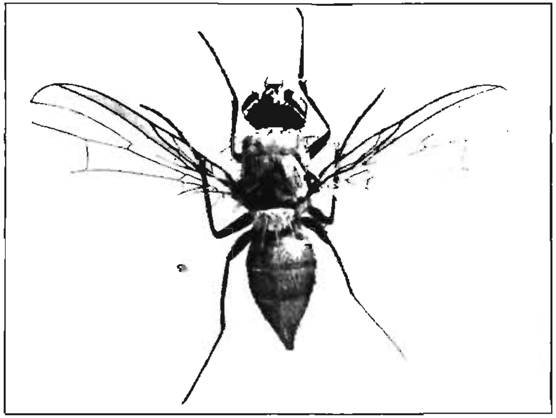

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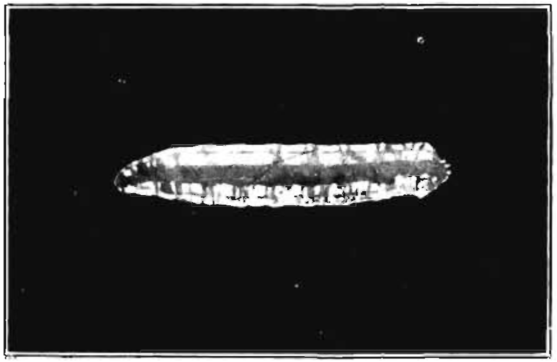

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Fig. 1. Wheat Bulb Fly (***Hylemyia coarctata***).
Fig. 2. Larva.
Fig. 3. Attacked Wheat Plant with Growing Point Destroyed.

ledge as to which fields will carry wheat the following year. Unfortunately for agriculture—and fortunately for the fly—wheat is usually sown on exactly those fields which during the previous summer were most attractive to the fly for egg-laying, *i.e.*, those which were fallows, or were cropped with potatoes and roots. It therefore follows that while many of the maggots must starve, the greater number will usually find themselves in a wheat field where they will flourish at the expense of the crop.

Methods of Control.—(1) From what has just been said it is clear that there is a danger in sowing wheat after fallows, potatoes, or where the land has been but lightly shaded by crops during the latter half of the previous summer. It is said that when the summer has been hot and dry the danger is much greater, and although the statement has not yet been proved it is likely to be correct as the flies will be more active in bright, warm weather than when it is cool and damp, while, further, under the latter conditions they are apt to suffer from the attacks of a fungus disease. In districts, therefore, where the Wheat Bulb Fly frequently causes loss, it is desirable to avoid sowing wheat in a field likely to be infested.

(2) If wheat must be sown on such fields, then early sowing is advisable in order that a strong plant may be obtained before Christmas. If a young plant has but one shoot it usually dies when attacked by the maggot, but if it has three or four strong tillers, it may lose two or even three of these tillers and still recover. An alternative course is to sow more seed than usual, with the idea that after the Wheat Fly maggots have killed a percentage of the plants, enough will remain to produce a crop. Thick sowing, however, checks tillering, and further, unless the Wheat Bulb Fly attack is very uniform, is likely to result in an excess of plants in parts of the field and not necessarily enough in the remainder. A heavy rate of seeding, therefore, is best reserved for cases where early sowing is impracticable.

(3) Where fallows can be sufficiently cleaned before the middle of June, a crop for ploughing-in or feeding-off may be sown in order to cover the land as soon as possible. In certain cases under observation mustard sown on bare fallows just before harvest did not entirely prevent a subsequent attack by Wheat Bulb Fly, presumably because it did not cover the ground soon enough. The attack, however, was not very serious and the wheat crop made a good recovery. If the cover crop had been sown earlier the loss might have been entirely prevented.

(4) When an attack is noticed, heavy rolling, which promotes tillering and assists the establishment of the plant, is of great value, provided it is done before the injury is too far advanced. In such cases it is preferable to risk the

injury resulting from rolling too early, rather than to delay the work until the wheat is crippled. In the case of fen soils, which are light and powdery in spring, very marked recovery may take place after rolling. If there is any doubt as to the land being in good heart, a light dressing of nitrate of soda is advisable.

(5) Early in April it should be possible to decide if sufficient wheat is left to promise a crop. If not, barley may then be sown with safety so far as the fly is concerned, and it may be used either with the remainder of the wheat as a mixed crop or alone. Any other crop which may be sown at this period of the year will be safe from attack if it is not desired to sow the cereal.

WIREWORMS.

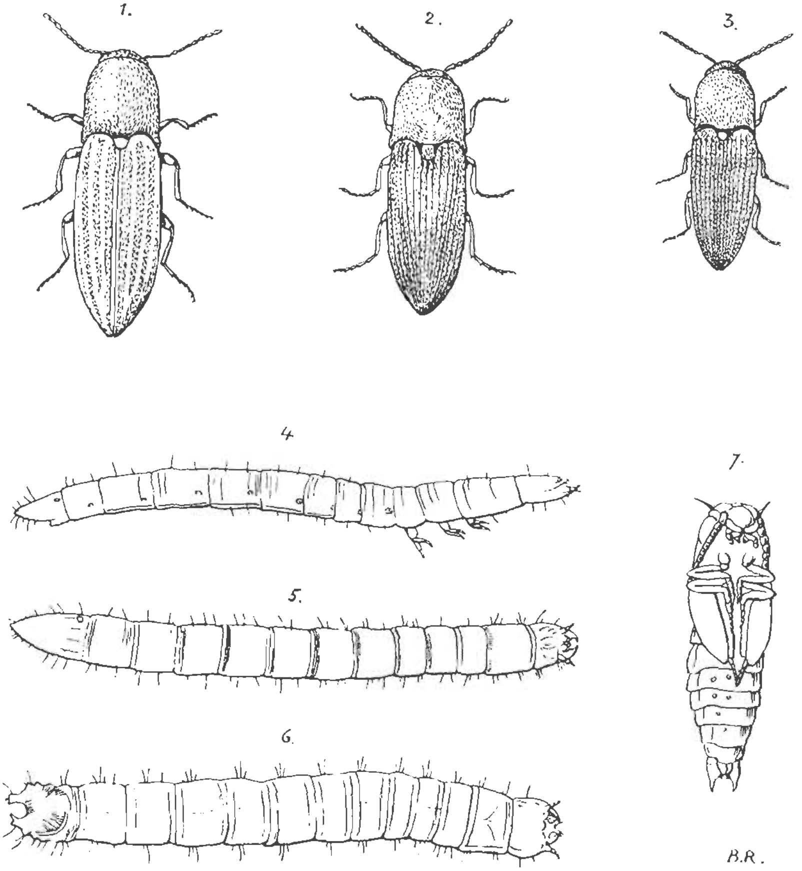
Wireworms are perhaps the most common and also the most widely distributed of all root feeding agricultural pests. They occur in practically every situation and in all classes of soil, and attack nearly every kind of crop. The loss to be attributed to them each year is very considerable, but their attacks are not epidemic and it is seldom possible to point out any district or year as being specially remarkable for their abundance. Because of their universal presence, there is a tendency to attribute all injury below ground to "wireworms," with the result that much confusion has arisen and the term "wireworm" is often applied to a number of distinct pests.

True wireworms are the larvæ or young of certain species of "click-beetle," and since they are easily distinguishable from other insect pests, confusion ought never to arise. An account of the features which distinguish the wireworm from other pests is given below.

In spite of the fact that wireworms are both abundant and troublesome much yet remains to be discovered with regard to the best methods of controlling their attacks. Statements in general are so contradictory that it is impossible to give authoritative advice until an extensive series of experiments has been carried out under modern conditions.

Description.—*Beetle.*—Adult wireworms are the beetles usually known as "click-beetles" or "skip-jacks" and their characteristic appearance is clearly shown by Figs. 1, 2, and 3. Like most beetles they possess two pairs of wings of which the front pair or "elytra" are horny and serve as a cover for the hind pair, which are the chief organs of flight.

The terms "click-beetle" or "skip-jack" have been given on account of the faculty of bending the front part of the body (head and prothorax) away from the remainder and then straightening it again with a sharp click. By this means the beetles are able to jump a short distance vertically



FIGS. 1, 2, 3. CLICK BEETLES (Adult Wireworms). Much enlarged.
Fig. 1.—*Agriotes lineatus*. Fig. 2.—*Agriotes obscurus*. Fig. 3.—*Agriotes sputator*.
FIGS. 4, 5, 6.—WIREWORMS. Much enlarged.
Fig. 4.—*Agriotes* wireworm (side view). Fig. 5.—*Agriotes* wireworm (upper surface).
Fig 6.—*Athous* wireworm (upper surface).
FIG. 7.—WIREWORM PUPA. Much enlarged.

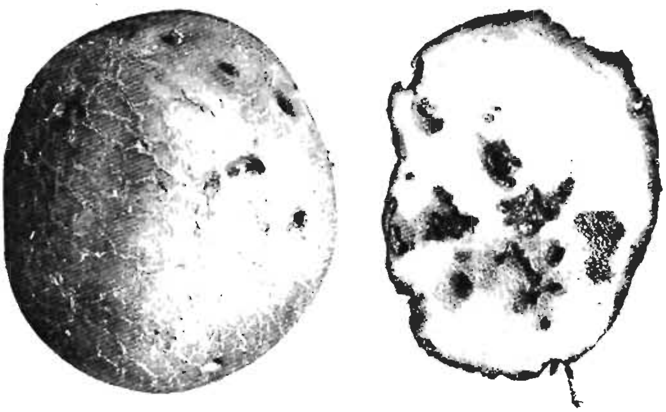


FIG. 8. POTATOES. To show wireworm damage.

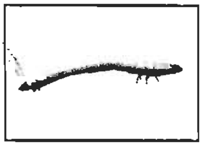


FIG. 9. -WIREWORM.
(Natural size.)

into the air, and to right themselves if placed on their backs, a position in which they would otherwise be somewhat helpless.

There are a large number of species of click-beetle in Britain, and, though they are much alike in form, they vary greatly in size, and their colour ranges from red and green to black. The majority, however, are harmless and there are only a few species which are important pests; these are all dull brown or black insects. (The chief offenders belong to the genera *Agriotes* and *Athous*, but wireworms of other genera—*e.g.*, *Lacon* and *Adrastus*—are sometimes troublesome.)

Larva.—The larvæ of click-beetles are the true wireworms. They are more or less elongate, worm-like insects, yellowish-brown or brown in colour, with a very hard skin which is usually highly polished. The head is darker than the body and is armed with powerful jaws. The three segments behind the head each carry a pair of legs, but the remaining segments are legless. The commonest species, those of the genera *Agriotes* and *Athous*, are shown in Figs. 4, 5, 6, 9. Wireworms may be distinguished from the other pests and animals with which they are most often confused, by the presence and number of the legs. Wireworms have only three pairs of legs and can therefore be easily distinguished from millepedes and centipedes, which have legs on almost every segment of the body. On the other hand worms have no legs at all and, therefore, confusion with them should be impossible. The same feature, *i.e.*, the absence of legs, will also serve to distinguish certain fly "maggots" which otherwise somewhat resemble wireworms.

Pupa.—The general appearance of a wireworm pupa is shown by Fig. 7. It is white in colour and differs from the larva in being very soft and easily injured. Wireworm pupæ are seldom seen and, owing to the time of year at which they occur, are not likely to be noticed in the ordinary cultivation of the land.

Eggs.—The eggs of *Agriotes* are milky white, opaque and nearly spherical, though slightly longer than broad. In size they are rather more than $\frac{1}{50}$ inch long, but vary slightly according to the species and also individually.*

Life-History.†—The eggs of the common wireworms are laid in June and July beneath the surface of the soil, in which the female beetle burrows for the purpose. Eggs may be found singly or in clusters of various numbers. The young larvæ emerge about a month after the eggs are laid and at once burrow into the soil. They are at first white and semi-transparent, but as they grow older their colour becomes

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* From a description by Mr. Rymer Roberts, of Rothamsted.

† The Ministry is indebted to Mr. Rymer Roberts, of the Rothamsted Experimental Station, for permission to make use of his unpublished notes on the biology of wireworms, and also to Messrs. Chittenden, Theobald, and Warburton for notes and suggestions.

more and more yellow. Growth appears to be slow at first, *and the first moult does not take place before the following* June. Probably the larvæ in their first stage feed principally on decayed vegetable matter in the soil, but there is some evidence that they also eat the living roots of plants. At the end of their first year's life when they have grown to the length of ¼ inch they have begun to feed freely on the *roots and underground stems* of all kinds of plants and these appear to form the greater part of their food for the remainder of their larval existence. (Wireworms are, however, in part carnivorous and attack both each other and many other animals which they meet in the soil.)

The exact period which the insect spends as a wireworm is not known, but at least in the case of *A. obscurus*, L., it is believed to be five years. When the larvæ are ready for pupation, which takes places during the latter half of summer, *they burrow down below the surface soil and hollow out* a small cell in the ground. The depth of the cell below the surface varies with the situation and nature of the soil, but it is seldom less than 6 inches deep and is more often from 8-12 inches. The object of descending seems to be to obtain a soil which is damp and of such a nature that the cell may be formed in it without risk of its subsequently falling in and pressing on the pupa. The depth is also of advantage in that predaceous insects are to a great extent avoided.

After a period of 3 or 4 weeks the beetle emerges from the pupa, but according to many authorities it still remains underground until the following spring, unless it is previously disturbed by cultivation. (This, however, is only partially correct, for both *Agriotes lineatus*, L., and *A. sputator*, L., frequently leave their cells without being disturbed in any way and may be found during the winter in tufts of grass, hedge bottoms or refuse of dykes. *Agriotes obscurus* seems more often to remain below ground and the same is probably the case with the *Athous*.)

In the adult state click-beetles of both genera may be found in the spring and summer crawling actively about or flying in the sunshine. They appear to feed to a certain extent on various leaves and, though they are not recorded as doing any damage in this country, this knowledge has been made use of in trapping them in order to reduce the numbers of the succeeding generation.

Nature of Damage and Economic Importance.—It is useless to give any *list of plants attacked* since it would include the majority of cultivated plants, while the nature of the damage in almost every case consists in the destruction of the roots or underground portions of the plant. Certain crops, such as beans (both Broad and Horse Beans) and clover, seem less liable to attack than others, while white mustard and rape are usually, but not invariably, immune.

There appear to be no records of damage being done to Linseed even when grown on badly infested land, but this crop is subject to the attacks of "leather-jackets" (Crane Fly larvæ). Grass land is often infested with wireworms, but it is usually able to support them without suffering appreciable loss.

In the case of cereals the damage is done when the crop is young, usually in the spring and early summer. Five or six consecutive plants in a row die and the stems below ground are found to have been eaten away. A further search usually reveals the wireworm at the roots of the next living plant and, if undisturbed, it will burrow along from plant to plant killing each as it goes. There seems to be no record in this country of an attack on the seed as is so often the case with the maize crop in America.

In the case of potatoes, Fig 8, the set is sometimes riddled by wireworms, and the crop may also be damaged in the same way, in some cases to such an extent as to be unsaleable.

A special form of injury is shown by tomatoes and beans. The wireworms attack the plant near the surface of the soil and then burrow up inside the stem for some inches above the surface of the ground—an unusual method of attack for an insect which lives in the soil.

As regards the general distribution of wireworms and the conditions favouring an attack, it has already been mentioned that they are always present in great numbers throughout the country, and from the fact that they live for five years it is evident that there may be five generations in the soil at the same time. They do not increase suddenly however and so form a definite epidemic as, for instance, in the case of the Diamond-back Moth (*Plutella maculipennis*) (*see* Leaflet No. 22, included in this volume). The types of vegetation which are usually most infested by wireworms are rough grass land, partly derelict, or weedy land, and it is when such lands are brought back into cultivation that a wireworm attack is most to be feared. Well cultivated land, however, is always infested to a certain extent, especially after "seeds" or grass lea.

Natural Enemies.—Both wireworms and click-beetles are eaten by various birds and animals. Wireworms are also parasitised by minute insects of the Order *Hymenoptera* and are also killed by one of the forms of fungus known as *Isaria*. It is impossible to estimate the extent to which these natural enemies assist in controlling the pest, but it is evident that they are *incapable* of checking it sufficiently under normal conditions.

Methods of Control.—*Agriculture.*—The chief object to be aimed at under agricultural conditions is to keep the pest continually in check by suitable cultivation, for it is seldom possible to apply chemical insecticides to large areas of land.

Experience shows that an attack is most to be feared after grass, leys, or when land has become foul. In order to reduce the wireworms as much as possible the best time to break up such land is in the latter half of summer—in the case of meadow land directly after the hay crop has been carted so as to make a bastard fallow. This course is specially to be recommended, since it not only checks the wireworm but also deals with the leather-jacket, which in some seasons is almost as bad a pest.

If the land cannot be ploughed until winter or spring the turf should be broken up—for instance, by disc harrows—and then well buried. The greatest importance must be attached to the thorough consolidation of the land, which, in many cases, is only attainable after the turf has been well broken up. A deep, firm seed-bed will often enable the subsequent crop to withstand a wireworm attack.

With regard to crops to be grown on infested land, it has already been mentioned that beans, peas, mustard and rape, and possibly buckwheat, are less susceptible to injury than cereals, while recorded attacks on flax are very rare. Such crops as mustard or rape are specially useful on land which cannot be prepared in time for more valuable crops, as they may be sown very late, and should form such a thick cover that the growth of weeds will be checked. It is often supposed that mustard has some effect on wireworm, apart from causing starvation, and in spite of statements to the contrary this possibility cannot be neglected, for wireworms are most difficult to starve, and yet a mustard crop is sometimes effective in cleaning infested land. If a relatively immune crop cannot be grown, potatoes may be taken on land which is somewhat infested, but if the wireworms are really numerous the risk to the crop is great. Corn crops perhaps suffer most of all, and this is specially the case when they are "standing still." A top dressing of sulphate of ammonia on autumn sown crops or the same manure put in with the seed in the case of spring sown crops will help the plant to grow away. Attention may again be drawn to the importance of consolidating the land by means of the roll.

With regard to "remedies" involving the use of insecticides, it is impossible at present to recommend any with confidence. They have not given consistent results and probably failures have been considerably more numerous than successes. If used they should not be allowed to take the place of the proper preparation and cultivation of infested land. Gas lime if fairly fresh applied at the rate of 4 tons to the acre seems to have been effective, and salt in heavy dressings—5-10 cwt. per acre—is sometimes recommended on light soils, but its value is doubtful. If either gas lime or salt (in heavy dressings) is used, it should be applied as long before the crop is sown as possible. Fragments of rape cake or rape dust have been found by some to be very attractive to the

pest, but here again the results of trials have been discordant and the verdict must at present be "not proven." There are various proprietary soil insecticides which are said to eradicate wireworms, but it is naturally impossible to discuss these claims in detail. The only advice which need be given here is to the effect that either a heavy dressing should be applied or the treatment be avoided altogether. A light dressing is likely to prove both a waste of money and of labour.

In general, thorough cultivation and clean farming keep wireworms more or less in check but it is impossible to eradicate them entirely.

Horticulture.—The remarks above as to the preparation of agricultural land apply equally to horticultural land, but it is even more advisable to spare no pains in the eradication of wireworms before the main crops are planted. Wherever it is possible an immune crop should be taken before land, especially grass land, is divided into allotments and gardens; the time spent in doing this will not be wasted.

The application of soil insecticides is more often possible under horticultural conditions than in agriculture, owing to the greater intrinsic value of each plant, but, apart from the proprietary compounds, there are few chemicals which are within the means of the average grower. These proprietary compounds usually depend for their action either on naphthalene or on substances of the carbolic acid and creosote types. The former are somewhat less fatal to insect life but have the advantage of being harmless to plants, while the latter are more deadly but can only be used as a rule on land which need not be planted for a time. Attention may be drawn again to the advice as to the application of sufficient dressings. Never less than the amount suggested by the maker should be used. Carbon bisulphide or carbon bisulphide emulsion may be used with success under special circumstances, as for instance for "disinfecting" heaps of grass turves, &c., rotting down to make potting soil, but they depend too much on suitable soil conditions for general application. The use of gas lime and salt has been mentioned in the previous section.

If the land is not badly infested or if soil insecticides are considered unsatisfactory, wireworms may be trapped. In this case pieces of potatoes, beet or carrot are spitted on short sticks and then buried in the ground. The stick enables the "trap" to be lifted and any wireworms attacking it can be destroyed.

The adult beetles may also be trapped in the spring and summer by means of small heaps of cut clover, sainfoin, or broken rape cake, covered with a tile or board. If desired these traps may be made poisonous with paris green to avoid the necessity of visiting them and removing the beetles, but in this case the covering must be sufficient to prevent animals from eating the poisoned bait.

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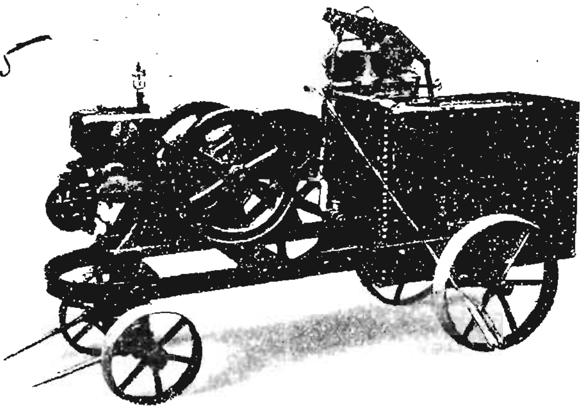

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